

# **Fast Gated Integrators And Boxcar Averagers**

Model SR250 – Gated Integrator and Boxcar Averager Module

Model SR255 – Fast Sampler Module

Model SR245 – Computer Interface Module

Model SR235 – Analog Processor Module

Model SR200 – Gate Scanner Module

Model SR280 – System Mainframe

Model SR275 – Display Module

Model SR240A – Fast Preamp



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**Stanford Research Systems**

1290-D Reamwood Avenue  
Sunnyvale, CA 94089 U.S.A.

Phone: (408) 744-9040 • Fax: (408) 744-9049  
Email: [info@thinkSRS.com](mailto:info@thinkSRS.com) • [www.thinkSRS.com](http://www.thinkSRS.com)

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


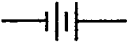



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## Symbols you may find on SRS products.

Symbol	Description
	Alternating current
	Caution - risk of electric shock
	Frame or chassis terminal
	Caution - refer to accompanying documents
	Earth (ground) terminal
	Battery
	Fuse
	On (supply)
	Off (supply)

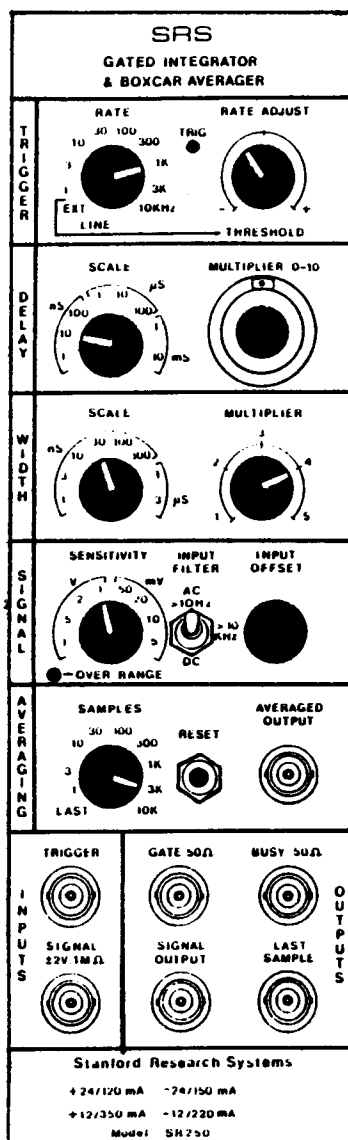
## INTRODUCTION

The model SR250 Gated Integrator is a versatile, high speed, low cost NIM module designed to recover fast analog signals from noisy backgrounds.

The SR250 consists of a gate generator, a fast gated integrator, and exponential averaging circuitry. The gate generator, triggered internally

or externally, provides an adjustable delay from a few nanoseconds to 100 milliseconds, before it generates a continuously adjustable gate of 2 nanoseconds to 15 microseconds. The delay may be set by a front panel potentiometer, or automatically scanned by a rear panel input voltage in order to record entire waveforms.

The fast gated integrator integrates the input signal during the gate. The output from the



### TRIGGER

The unit may be triggered internally or externally. The internal rate generator is continuously variable from 0.5Hz to 20KHz in 9 ranges. The external trigger pulse may be as short as 5nS. A green LED blinks with each trigger.

### DELAY

The delay of the sample gate from the trigger is set by these controls. The delay scale is multiplied by the setting on the 10-turn dial, allowing continuously adjustable delays from a few nanoseconds to 100mS. The delay multiplier may also be controlled by a rear panel input voltage for scanning gate applications.

### WIDTH

The width of the sampling gate may be continuously adjusted from 2nS to 15μS over 8 width ranges.

### SIGNAL

The sensitivity of the instrument (volts out/volts in) may be set from 1V/1V to 1V/5mV. An input filter rejects unwanted signal before it is sampled by the integrator. A 10-turn INPUT OFFSET control may be used to compensate for an unwanted input offset.

### AVERAGING

An AVERAGE OUTPUT provides a moving average over 1 to 10K samples. The reset button is used to reset the average to zero. The average may also be reset by a rear panel logic input.

### INPUTS

Both the TRIGGER and the SIGNAL inputs have a 1MΩ input impedance and may safely handle 100 volt inputs without damage.

### OUTPUTS

The SIGNAL INPUT is passed out to the SIGNAL OUTPUT for termination and for gate timing: The GATE output shows exactly which portion of the input signal is being sampled. The BUSY output provides a TTL synchronizing pulse when the unit is triggered. The LAST SAMPLE output provides a voltage proportional to the latest input signal averaged over the gate.

Figure 1 - SR250 Front Panel

**SPECIFICATIONS****TRIGGER**

Internal Trigger	The rate generator is continuously adjustable from .5Hz to 20KHz in 9 ranges.
Line Trigger	The gate generator may be triggered from the power mains with adjustable phase.
External Trigger	The gate generator may be triggered by the EXTERNAL TRIGGER INPUT. 1 M $\Omega$ input impedance. Trigger threshold adjustable from 0.5 to 2V. The input is protected to +/- 100 VDC. The trigger pulse must be over threshold for at least 5nS and have a rise time shorter than 1 $\mu$ S.
Manual Trigger	The unit will trigger once if the trigger threshold is scanned through 0 VDC.
Trigger LED	The Trigger LED blinks with each trigger.

**DELAY**

Delay Scale	Delay scales from 1 nS to 10 mS may be selected.
Delay Multiplier	A 10-turn dial is used to select a delay multiplier from 0 to 10.
Accuracy	2 nS or 5% of the full scale delay, whichever is larger.
Jitter	Less than 20 pS or 0.01% of the full scale delay, whichever is larger.
External Delay Control	Rear panel input voltage from 0 to 10 VDC overrides the front panel delay multiplier. This input is used by the SR200 Gate Scanner Module to scan the sample gate in order to record entire waveforms.
Note:	A trigger discriminator delay of about 25 nS must be added to the gate delay when external triggers are used.

**WIDTH**

Width Scale	1, 3, 10, 30, 100, 300nS, 1, 3 $\mu$ S.
Width Multiplier	Continuously adjustable from x1 to x5.
Width Accuracy	2nS or 20% of full scale, whichever is greater.
Minimum Width	2nS, FWHM.

**SIGNAL**

Sensitivity	The sensitivity, volts out/volts in, may be set from 1V/1V to 1V/5mV in a 1, 2, 5 sequence. The sensitivity calibration is accurate to 3% for gate widths longer than 10 nS. The sensitivity decreases to about 50% of nominal at a gate width of 2 nS.
Filter	An input filter allows coupling of DC, AC above 10 Hz, or AC above 10 KHz.
Offset Control	A 10-turn potentiometer adds an input offset of $\pm 0.4$ VDC. When using very narrow gates, the offset may need adjustment if the gate width is changed.
Over Range LED	A red LED indicates if the signal is greater than 2 VDC or if the LAST SAMPLE output is greater than 10VDC.

**LAST SAMPLE**

Output	A $\pm 10$ VDC full scale output with an output impedance of less than 1 $\Omega$ and a 10mA drive capability. The short circuit output current is limited to about 20mA. The droop rate at this output is less than 0.2% of full scale per second.
Polarity	The polarity of the LAST SAMPLE output may be inverted by a rear panel switch.
Responsivity	95% (no more than 5% of the previous last sample remains.)

**AVERAGING**

Samples	An exponential moving average may be taken over 1, 3, 10, 30,... to 10,000 samples or LAST may be selected for no averaging.
Reset	Front panel push button resets the moving average to zero.
Remote Reset	Rear panel BNC input resets the moving average with TTL low or switch closure.
Average Output	BNC output, $\pm 10$ VDC full scale, with an output impedance of less than $1\Omega$ , and a 10mA drive capability. Short circuit current limits at about 20mA. When there are no triggers the droop rate is less than 1% per minute on 1 to 30 samples, and less than 0.01% per minute for 100 to 10K samples in the average. This implies a droop error of less than 1% of full scale for trigger rates $>1$ Hz.
Average Polarity and Baseline Subtraction	A rear panel switch selects the polarity of the LAST SAMPLE before it is added to the moving average. This may be used to invert the polarity of the AVERAGE OUTPUT. The switch may also be set to the TOGGLE position, in order to subtract every other sample from the moving average. By triggering the unit at twice the experiment's repetition rate, so as to sample only the baseline on alternate triggers, the baseline will be subtracted from the moving average.
Toggle Output	A rear panel BNC provides a TTL signal that changes state with each trigger. This output is used with the Active Baseline Subtraction feature to indicate if the next sample will be added to, or subtracted from, the moving average. The toggle output is capable of driving $50\Omega$ lines to +2 VDC.

**SIGNAL INPUT AND OUTPUT**

Signal Input	$1M\Omega$ input impedance, $\pm 2$ VDC usable range, protected to 100 VDC. The input offset drift is less than 0.5mV per hour after a 20 minute warm-up. Shot noise at the input is less than 0.5mV. Coherent pickup is less than 5mV, which may be cancelled with the input offset control in fixed gate applications.
Signal Output	The SIGNAL OUTPUT is the input signal delayed by 3.5nS. This output is used to terminate the input signal, and to precisely time the sample gate with respect to the output signal.

**GATE AND BUSY OUTPUTS**

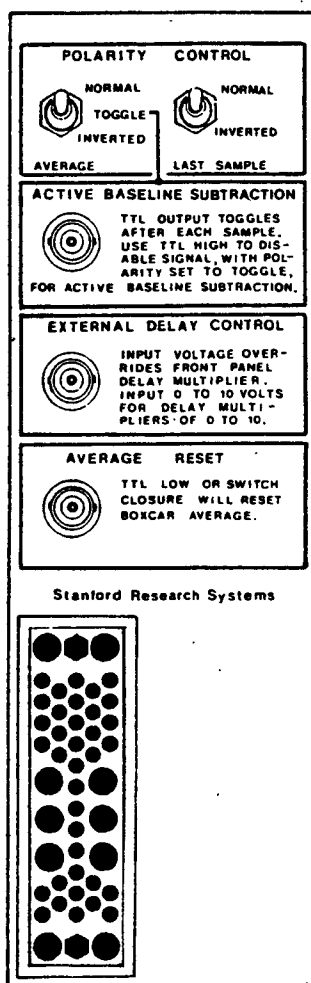
Gate Output	A 200mV output pulse marks the exact position of the sample gate with respect to the output signal. Position accuracy is $\pm 1$ nS. This output must be terminated into a $50\Omega$ load.
Busy Output	This TTL output is used to synchronize the experiment to the internal rate generator (if it is used) or to signal the data acquisition computer that the unit has been triggered. The output will drive $50\Omega$ lines to 2 VDC, and is logic 1 from the time of the trigger until the unit is ready to accept another trigger input. (A minimum of 45 $\mu$ S, longer for long delays or gate widths.)

**GENERAL SPECIFICATIONS**

Power Supplies	+24V/135mA, +12V/380mA, -12V/230mA, -24V/150mA. Approximately 14 Watts. Power from a NIM standard crate or from Stanford Research Systems mainframe model SR280.
Mechanical	Dual width NIM standard enclosure per TID-20893. Dimensions 2.7"x8.714"x11.5".
Warranty	1 year parts and labor on defects in materials or workmanship.

integrator is then normalized by the gate width to provide a voltage which is proportional to the average of the input signal during the sampling gate. This signal is further amplified according to the front panel sensitivity setting. Then it is sampled by a low droop sample and hold amplifier, and output via a front panel BNC connector. This LAST SAMPLE output allows the experimenter to do a shot-by-shot analysis of the signal being studied, and makes the instrument a particularly useful component in a computer data acquisition system.

A moving exponential average over 1 to 10,000 samples is available at the AVERAGED OUTPUT. This traditional averaging technique is useful for pulling small signals from noisy backgrounds. As one averages many noisy samples of a signal, the average will converge to the mean value of the signal, and the noise will average to zero. In the case of a random white noise background, the signal-to-noise ratio increases as the square root of the number of samples in the average. This allows a S/N improvement of a factor of 100 using this technique alone.



#### POLARITY CONTROL AND ACTIVE BASELINE SUBTRACTION

The Polarity of the Last Sample and Averaged Outputs is controlled by rear panel toggle switches. If the Average switch is in the Toggle position the polarity of the last sample is inverted on every other shot before being added to the moving average. This feature is used to subtract the baseline from the Average Output. For this feature to operate, you must use the Active Baseline Subtraction logic output to disable the experiment on alternate triggers. The Last Sample Polarity control provides a simple way to interface the device to unipolar ADC's.

#### EXTERNAL DELAY CONTROL

The External Delay Control Input allows the user to control the Gate Delay with a voltage. The voltage applied to this input overrides the front panel delay multiplier.

#### AVERAGE RESET

The Average Reset input will accept a TTL low level or a switch closure to ground to reset the moving average output. If the input is held low for at least 1 $\mu$ S, a 2mS reset pulse is generated internally, resetting the moving average.

Figure 2 - SR250 Rear Panel

In addition to this traditional technique, the averaging circuitry may be used to actively subtract a baseline drift or background from the signal of interest. This is accomplished by taking input samples at twice the repetition rate of the experiment, inverting the baseline sample acquired when the signal is not present, and adding it to the moving average. This method of cancelling baseline drift is analogous to phase sensitive detection which is used in frequency domain measurements.

## OPERATION

This section will describe the operation of the SR250 Gated Integrator and Boxcar Averager Module. The instrument's controls and input and output characteristics will be discussed.

While there are several modes of operation, by far the most common application of the SR250 is to sample an input voltage at a fixed time from an input trigger. The time delay from the input trigger to the start of the sample gate is set by the front panel delay controls: the width of the sample gate is set by front panel delay controls.

### EXTERNAL TRIGGER INPUT

The gate generator is usually triggered externally. The external trigger input should be a clean signal: if the trigger is marginal or noisy, then the gate will jitter in time. You should avoid excessive high frequency noise on this or on any other input or output to the Boxcar (such as may be created by laser Q-switches, discharges, or spark gaps). Other important characteristics of the trigger signal are:

**Amplitude:** The trigger pulse must be at least 0.5 volts, preferably should not exceed 5 volts, and in no case is to exceed 100 volts. Positive or negative trigger inputs are okay. The trigger threshold is set between 0.5 volts and 2 volts by the threshold knob. The unit will trigger when the trigger input exceeds the set threshold.

**Duration:** For reliable triggering, the trigger must remain over threshold for at least 5 nanoseconds.

**Risetime:** The trigger input is AC coupled to the trigger discriminator. The time constant of this

circuit is about  $10\mu\text{s}$ , therefore, external trigger inputs must have a risetime of less than  $10\mu\text{s}$ . This AC coupling makes the trigger circuit immune to DC shifts at the trigger input, and allows the unit to trigger on the falling edge of a long positive logic pulse. If the logic pulse is high for at least a few milliseconds, then the unit may be triggered on the differentiated falling edge of the pulse by setting the trigger threshold to a small negative value.

**Frequency:** The maximum external trigger rate is 20KHz. This maximum is reduced if long gate widths or delays are used. The external trigger source should not try to trigger the unit while the BUSY output is high, otherwise the trigger may be missed or the unit may trigger erratically.

### DELAY

When triggered, the unit will generate a gate, and the input signal will be sampled while the gate is on. The delay from the input trigger to the start of the sample gate is set by the front panel delay controls. A DELAY SCALE of 1nS to  $10\mu\text{s}$  may be selected. The DELAY MULTIPLIER, a 10-turn dial, may be set from 0 to 10.0. The actual delay is equal to the DELAY SCALE times the DELAY MULTIPLIER, plus a nominal 25nS trigger discriminator delay.

### WIDTH

The width of the sample gate is set by the front panel width controls. Gate widths from 2nS to  $15\mu\text{s}$  may be set by selecting the appropriate WIDTH SCALE and WIDTH MULTIPLIER. Do not select gate widths shorter than 2nS, since the sensitivity of the instrument reduces dramatically under these conditions.

### SIGNAL INPUT

The signal to be sampled is applied to the signal input. This input has a 1 M $\Omega$  input impedance, and is passed to the SIGNAL OUTPUT via 3.5nS of internal coax delay line. In many applications, the signal cable should be terminated into 50 $\Omega$ . If it is necessary to terminate the input signal this should be done at the SIGNAL OUTPUT BNC connector, and not at the SIGNAL input. The input signal should not exceed  $\pm 2$  volts, otherwise the instrument's input buffer amplifier may saturate. If this happens, the OVER RANGE LED will turn on.

Input signals with a DC component of up to 50 VDC are okay if the INPUT FILTER is on either the 10Hz or 10KHz range. The SIGNAL input is protected against damage for input signals up to 100 VDC.

### GATE OUTPUT AND SIGNAL OUTPUT

The GATE and SIGNAL OUTPUT show the exact timing relation of the sample gate with respect to the signal. The sample gate position is marked by a +200mV output pulse. To overlap the sample gate onto a particular portion of the signal, use equal lengths of coax cable to bring the GATE and SIGNAL OUTPUT to the inputs of a dual channel oscilloscope. The GATE output cable should be terminated into a 50Ω load. You may also need to terminate the SIGNAL OUTPUT cable into 50Ω. Trigger the oscilloscope with the Boxcar's BUSY output, and adjust the DELAY MULTIPLIER to position the gate output with respect to the signal output. The timing accuracy of the gate and signal outputs is 1nS.

### SENSITIVITY

The SENSITIVITY switch selects the gain of the instrument in volts out/volts in. The sensitivity may be set from 1V/V up to 1V/5mV. The OVER RANGE LED will turn on if the sum of the input signal and the input offset, averaged over the sample gate, exceeds ten times the sensitivity (i.e. the LAST SAMPLE output exceeds 10VDC). You can make the OVER RANGE LED go off by (1) reducing the SENSITIVITY setting, (2) adjusting the INPUT OFFSET control, (3) reducing the signal amplitude, or (4) by changing the INPUT FILTER.

### INPUT OFFSET

This 10-turn knob is used to add a DC offset to the input signal. The offset may be set from +0.4 to -0.4 VDC. Note that this is an offset control, as opposed to a position control, and behaves accordingly when the SENSITIVITY switch is changed. Also, this input offset is not affected by the position of the INPUT FILTER switch.

### INPUT FILTER

The INPUT FILTER switch allows you to reject unwanted signal components before they get to the gated integrator. DC drifts are eliminated on

either AC range. The AC filters have a 6 dB/octave roll-off, and so the 10KHz filter will reject 99.6% of an unwanted 60Hz noise signal. On either AC range the input is capacitively coupled, allowing photomultiplier anodes to float up unless an external resistance to ground is provided.

### LAST SAMPLE OUTPUT

The LAST SAMPLE output has a full scale range of ±10VDC. The output is able to drive any load greater than 2KΩ to full scale. The output impedance is less than 1Ω, and has a short circuit current limit of 20mA. The analog voltage, V, at the LAST SAMPLE output, valid after the BUSY output returns to its low state, is given by:

$$V = \frac{\text{Average of Input during Last Gate}}{\text{Sensitivity Setting}}$$

The polarity of the LAST SAMPLE output may be inverted by a rear panel switch. You may wish to invert the LAST SAMPLE output in order to obtain a positive output from a negative photomultiplier input.

### AVERAGING

The AVERAGED OUTPUT provides an exponential moving average over the number of samples specified by the SAMPLES selector. If 300 samples are selected for the moving average, the AVERAGED OUTPUT will come to 67% of its final value after 300 triggers. The RESET button may be used to reset the moving average to zero. A rear panel BNC input may also be used to reset the moving average. The AVERAGED OUTPUT has an output impedance of less than 1Ω and a short circuit current limit of about 20mA. The polarity of the AVERAGED OUTPUT may be inverted by a rear panel switch. This switch also allows the polarity of the current sample to be inverted on alternate triggers, a feature that is used in the ACTIVE BASELINE SUBTRACTION mode, which will be described later.

The averaging circuits use a sample and hold amplifier which has a very small drift that can be neglected in most applications. When triggering stops, the AVERAGED OUTPUT drifts less than 1% per minute on 1 to 30 sample averages and less than .01% per minute for 100 to 10K sample averages. This implies an error of less than 1% of

full scale in any moving average for which the trigger rate is greater than 1Hz.

### BUSY OUTPUT

The BUSY output is a TTL output, capable of driving 50 $\Omega$  loads to 2VDC, which goes high from the time the unit is triggered until the unit is ready for another trigger. The BUSY output goes high for a minimum of 45 $\mu$ S, but will stay high longer if long gate delays or widths are selected. The BUSY output has several uses, including: (1) indicates when the unit is busy, and so when external triggers should not be applied, (2) may be used to trigger other Boxcars, (3) may be used to synchronize an experiment to the Boxcar's internal rate generator, (4) may be used to tell the data acquisition computer that the unit has been triggered and that a new sample is available, and (5) may be used to trigger an oscilloscope to help time the sample gate with respect to the signal of interest. Although it is not necessary to terminate the BUSY output to 50 $\Omega$ , it is advisable. The BUSY output has a 1nS risetime and so a substantial reflection will occur if the it is not terminated.

### ACTIVE BASELINE SUBTRACTION

In addition to the passive baseline subtraction described in the examples, there is another method of eliminating baseline drift called Active Baseline Subtraction. This feature allows the Boxcar Module to subtract baseline drift from the AVERAGED OUTPUT signal. The baseline is removed by taking samples at twice the repetition rate of the experiment, inverting the sample taken with no signal present (only baseline), and adding it to the moving average. This technique is similar to phase sensitive detection in that the baseline, which is not synchronous with the signal, is cancelled from the output. To use this feature the AVERAGE POLARITY CONTROL switch on the rear panel must be set to the TOGGLE position, which will automatically invert the LAST SAMPLE on every other trigger before it is added to the moving average. Of course, the signal must be present only on every other sample, so that only the

baseline is subtracted from the moving average. To facilitate this, a rear panel output, ACTIVE BASELINE SUBTRACTION, will toggle with each trigger to tell the experiment when to allow and when to inhibit the signal. The INPUT OFFSET control may appear not to work when in this mode, however this input offset is actually being cancelled from the moving average. When using Active Baseline Subtraction you should average over 30 or more pulses in order to avoid a choppy AVERAGED OUTPUT signal. Proper adjustment of the INPUT OFFSET control will also help reduce this effect.

### EXTERNAL DELAY CONTROL

A control voltage applied to this rear panel BNC input overrides the front panel DELAY MULTIPLIER dial. The delay control voltage may be set from 0 to 10.0 VDC. This control input may be used to scan the sample gate in order to record entire waveforms. The input impedance varies from 10K $\Omega$  to 16.6K $\Omega$  depending on the DELAY MULTIPLIER dial setting; this impedance terminates to a voltage equal to the DELAY MULTIPLIER setting. There are two consequences of these input characteristics: (1) control signals applied to this input should come from a low impedance source (such as the SR200 Gate Scanner Module), and (2) you may use the EXTERNAL DELAY CONTROL input as an output in order to read the DELAY MULTIPLIER dial setting. The output impedance also depends on the delay setting, from 10K $\Omega$  at 0.0V to 16.6K $\Omega$  at 10.0V. Beware that if you draw current from this 'input' the DELAY MULTIPLIER will be affected, and may appear to be malfunctioning.

### AVERAGE RESET

As previously described, the AVERAGE RESET input may be used to reset the voltage at the AVERAGED OUTPUT to zero. This input has an internal 10K $\Omega$  pull-up to +5VDC. A TTL low or switch closure to ground will reset the moving average. The input must be held low for at least 1 $\mu$ S, which will trigger an internal 2mS reset pulse which clears the averaging capacitors.



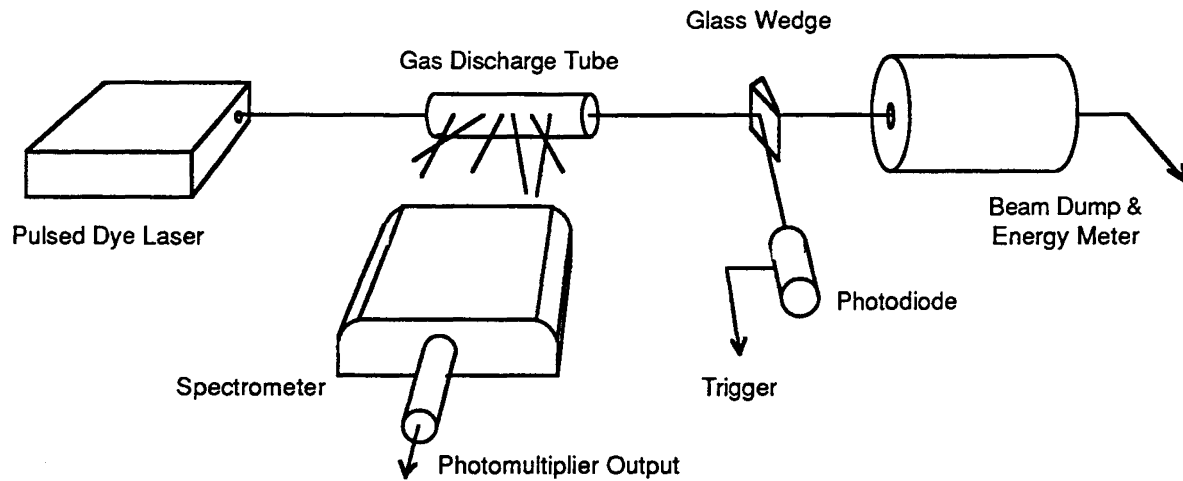


Figure 3 - Experiment For Application Examples

## APPLICATIONS

This section will illustrate some specific operating examples using the SR250 Gated Integrator, together with other Boxcar System components. Although the specific examples involve data acquisition in pulsed laser experiments, many of the concepts and techniques introduced in these examples are applicable in other areas of research.

### PULSED LASER DATA ACQUISITION

In this example, excited state atoms in a gas discharge are to be transferred to a different excited state by a pulsed dye laser. Figure 3 shows the experimental arrangement for this and the other examples. The transfer will be inferred by the increased fluorescence from the final state as the dye laser frequency is tuned through the transition frequency. The experiment is difficult because the background fluorescence signal from final state atoms excited by the discharge is larger than the laser induced signal. The desired result is shown in Figure 4.

Other details of the experiment, are shown in Figure 5, and summarized here:

- 1) The laser pulse width is 8nS.
- 2) There is a 40nS delay in the photomultiplier, from the time photons strike the photo-cathode until the anode signal is seen.
- 3) Decays from the final state are very fast; the lifetime is less than the laser pulse length.
- 4) The laser induced signal is expected to be only 25% of the background and is only present during the laser pulse. The experimenter wants a final Signal/Noise ratio of 5:1.

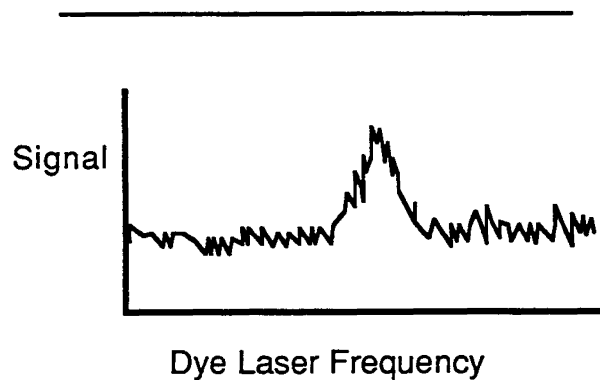


Figure 4 - Desired Result for Example 1

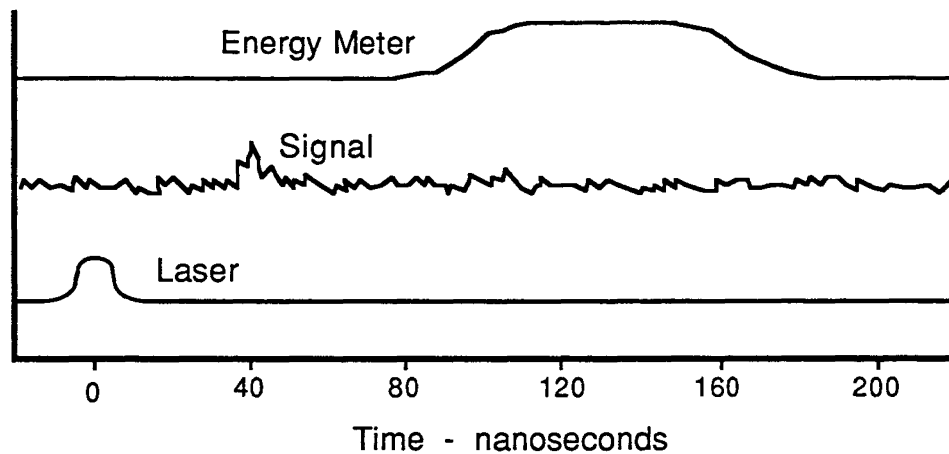


Figure 5 - Experimental Timing Details

The Boxcar Averager system for this experiment is shown in Figure 6. The SR280 Mainframe bar-graph display is used to show shot-by-shot data, while the digital and analog panel meters are used to display the Boxcar outputs. The timing of the sample gate with respect to the laser induced signal is a very important aspect of this signal recovery problem. To maximize the S/N of the result it is important to gate the integrator open only while the S/N is favorable: we must be certain to look only during the 8nS laser pulse. To simplify this timing, the SR250 has signal and gate outputs; the signal output is the same as the signal input, but internally delayed by 3.5nS of coax cable. This delay is added to provide an exact coincidence between the signal and gate outputs. Using a dual channel oscilloscope, usually in the ADD mode, the gate can be accurately positioned over the portion of the signal for which the laser is on.

As shown in Figure 3, a reflection of the laser off a glass wedge is used to trigger the unit via a fast photodiode. The BUSY output from the SR250 is used to trigger the oscilloscope, and equal lengths of cable are brought to the oscilloscope's A and B inputs from the GATE and SIGNAL OUTPUT for the gate timing. The gate can now be accurately positioned over the signal by adjusting the DELAY MULTIPLIER. (If the laser induced signal is too small

to be seen for timing purposes, one could tune the spectrometer to the laser frequency and rely on scattered laser light to time the gate to the signal.) Because the photomultiplier delay (about 40nS for a 12 stage PMT) is greater than the 25nS minimum gate delay of the SR250, no cable delay is required to slow the signal from the PMT. And, since the unit is triggered by the laser light, there will be virtually no jitter of the gate with respect to the signal. Low timing jitter is important, as we will be using an 8 to 10nS gate in this experiment. If, because of a long trigger delay, we were forced to use a less stable trigger, the S/N of the experiment would be adversely affected.

In this hypothetical experiment, the S/N of each sample is 1:4. To achieve the desired 5:1 S/N an enhancement of 20 is needed, requiring that about 400 shots be averaged. Knowing this, we select the closest averaging interval, 300 samples, which will give a S/N enhancement of a factor of 17. If the laser is operating at 10 Hz, the effective time constant is 30 seconds: we must be sure not to scan the laser through the transition too quickly.

Data is recorded by displaying the average output on the y-axis of a strip chart recorder as the laser is slowly scanned over the frequency region of interest.

## THE BASELINE PROBLEM

In the preceding experiment, we would have used the 10KHz input filter on the signal input: there are no signal components of interest below 10KHz, and so this measure will reduce low frequency noise (i.e. 60Hz and baseline drift).

You may wish to reject even higher frequencies. There are at least two good ways of doing this. The first is to insert a small capacitor in series with the signal input. If the signal line remains terminated into 50Ω at the oscilloscope, and we use a 470pF capacitor, then frequencies below 6.7MHz will be rejected with a 6dB per octave low frequency roll-off.

The second method is actually a very effective method of baseline subtraction. To use this method, after completing the fast timing of the signal and the gate, terminate the SIGNAL OUTPUT into a short circuit. (Make sure that this will not damage your detector.) This probably seems like a

very bad idea at first, but recall that there is 3.5nS of coax cable between the SIGNAL input and SIGNAL OUTPUT. The 100% (inverted) reflection from the short will not be seen at the input for  $2 \times 3.5 = 7\text{nS}$ . The inverted reflection (which is the baseline at a time 7nS prior to the signal) is superimposed on the input when it is sampled by the gated integrator. If you want to sample the baseline more than 7nS before the signal, just add some additional coax to the SIGNAL OUTPUT before terminating it into a short.

You may want to subtract the baseline just following your signal (rather than the baseline just before). To do this, we are going to sample the reflected signal, superimposed on the baseline (which follows the signal in time). When you do this, you must, of course, move the gate later in time, by an amount equal to  $2 \times (3.5\text{nS} + \text{length of your shorted coax})$ . Since you're sampling the reflected signal pulse, it will be inverted—you may fix this with the output polarity controls on the back panel of the SR250.

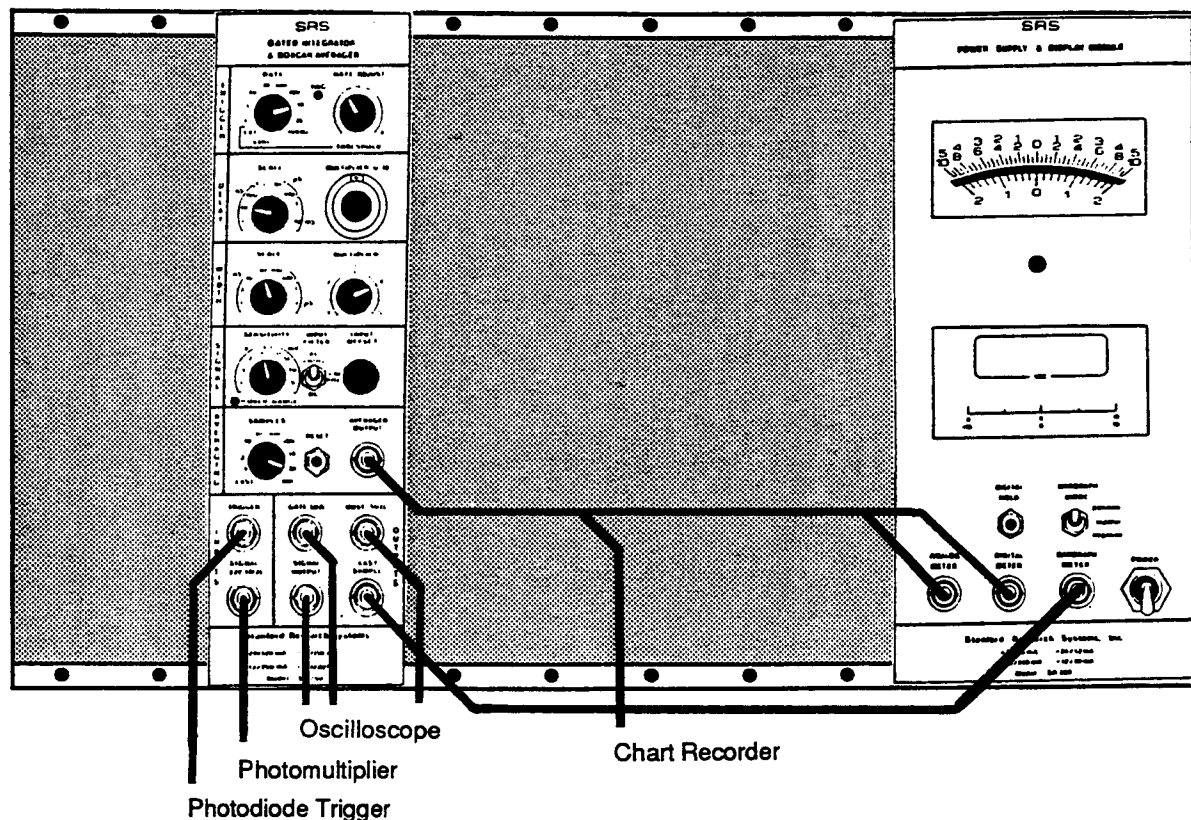


Figure 6 - Boxcar System for Example 1

### EXAMPLE 2

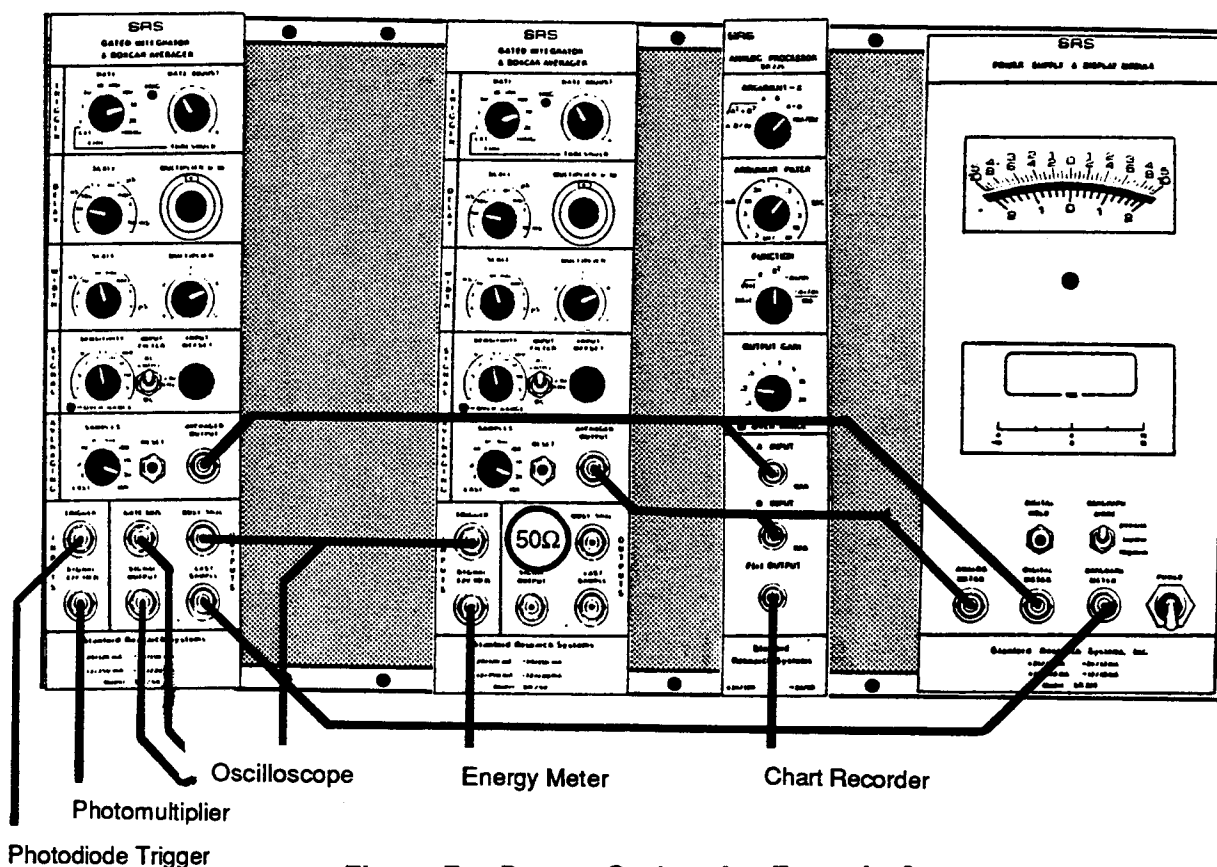
Essentially the same as Example 1, only this time we want to normalize the fluorescence signal to the laser intensity. The Boxcar Averager System for this experiment is shown in Figure 7. In this instance, the Mainframe display meters are used to show the signal intensity shot by shot, the averaged signal intensity, and the averaged laser intensity. The fast timing of the signal is done as before, and Passive Baseline Subtraction done with a shorted coax cable attached to the Signal Output. A second SR250 is used to integrate the output of an energy meter. The time response from the energy meter is much slower than from the PMT, and so we will use a much longer gate at a later time to sample its output. This is possible because all the boxcar modules have entirely independent gates. Both boxcar units are set up to average over 300 samples, and the second Boxcar is triggered from the BUSY output of the first Boxcar. The average outputs are ratioed in an SR235 Analog Processor, and the result, Signal

Intensity vs. Laser Energy, is displayed on a strip chart recorder.

In order to extend the dynamic range of this experiment, we could select  $F(x)=\ln(a/b)$  from the Analog Processor. This would display signal changes between 10mV and 100mV as predominantly as changes between 1V and 10V.

### EXAMPLE 3

In this example, we want to record the lifetime of the excited state by observing the exponential decay of the population from that state. To do this, we will tune the laser in order to promote atoms to the state of interest, and slowly scan the gate delay, recording the normalized signal intensity versus gate delay. The Boxcar Averager System for this experiment is shown in Figure 8. Here, the Mainframe display meters are used to show the laser intensity (shot by shot as well as the moving average) and the averaged signal intensity. For an excited state with a lifetime of 50nS the expected



**Figure 7 - Boxcar System for Example 2**

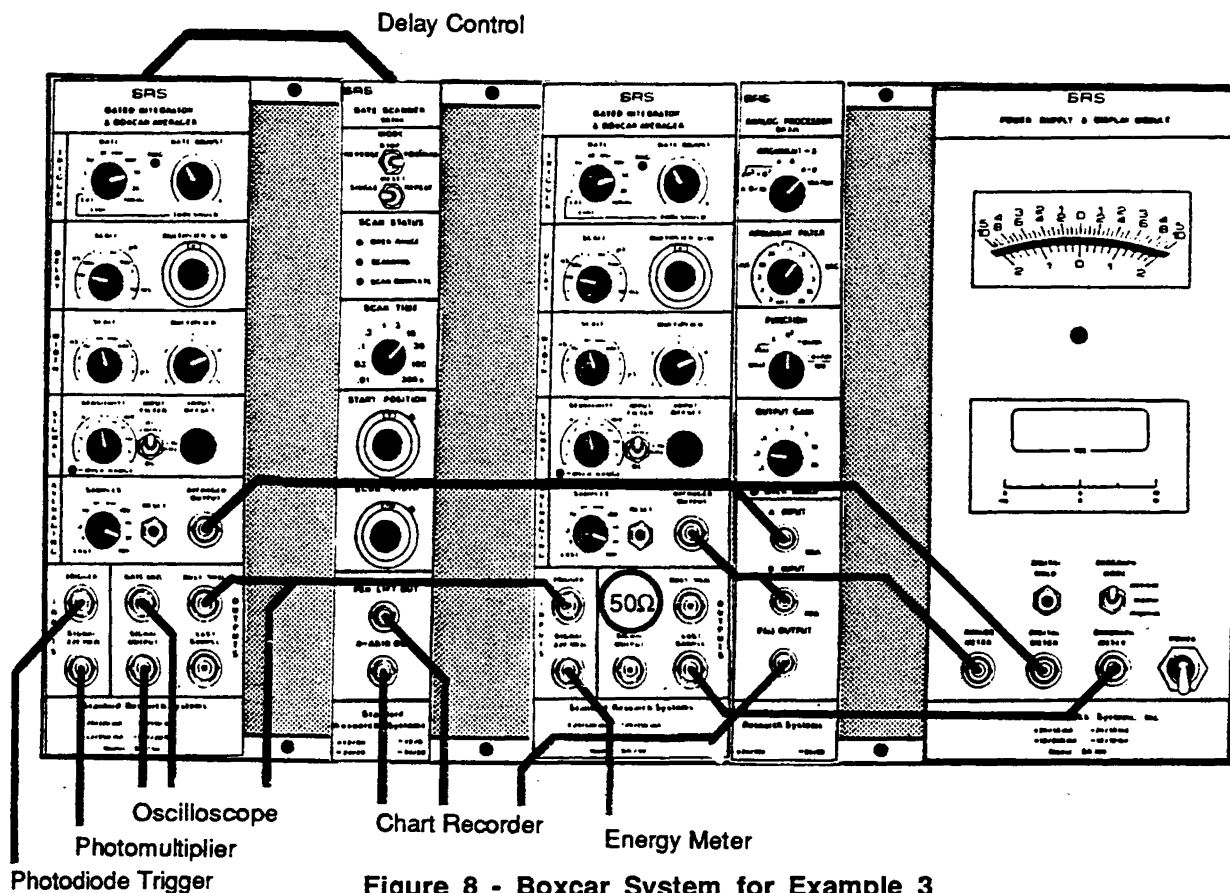


Figure 8 - Boxcar System for Example 3

result is shown in Figure 9. The SR200 Gate Scanner Module is used to slowly scan the gate, and to provide x-axis and pen-lift controls to the chart recorder. This module provides a control voltage to the Boxcar which overrides the front panel delay multiplier. (Electronically turning the delay multiplier knob, if you will.)

Depending on the number of samples being averaged, it is possible to scan the gate too fast. Scanning too fast will distort the shape of the decay curve, a bad thing as we are trying to measure the lifetime of the excited state from this curve. A very simple way to judge if this distortion is occurring is to compare the scan with one taken backwards, i.e., from long delays to short delays. The SR200 allows scans in either direction, controlling the chart recorder motion properly in either case.

An obvious extension of Example 3 would be to display the log of the intensity normalized signal on the chart recorder. Doing so will remove any laser

intensity fluctuations, allow direct measurement of the state's lifetime (now a straight line on the chart recorder), and extend the dynamic range of the experiment.

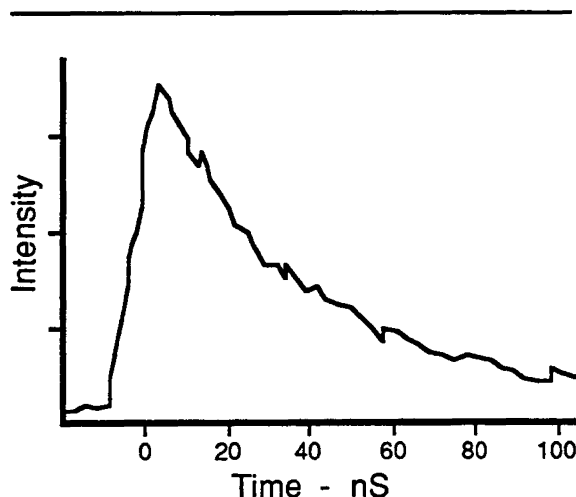


Figure 9 - Desired Result for Example 3

**NOTES ON COMPUTER INTERFACE**

Several improvements in the operation of these experiments can be achieved by controlling the experiment and the data acquisition by a laboratory computer. The unique ability of the Gated Integrator Module to provide shot-by-shot data dramatically increases the instrument's utility. The LAST SAMPLE output (or AVERAGED OUTPUT) can be digitized by the SR245 Computer Interface Module and sent to the lab computer via RS232 or GPIB. As an example of how a small computer could be used, consider Example 1. In this case, the effects of long term drift can be virtually eliminated by having the computer average the

results of many short scans, rather than suffering the consequences of the long term drift in a single long scan.

**INTERNAL TRIGGERING**

In all of the preceding examples, the unit has been externally triggered. The trigger section of the SR250 also contains a rate generator which is able to trigger the unit at any frequency between 0.5Hz and 20KHz. When internally triggered, you will want to use the BUSY output as a trigger for your experiment. The BUSY output has a fast rising edge (about 1nS) which precedes the earliest possible gate by about 10nS.

---

## TIMING SPECIFICATIONS

SYMBOL	DESCRIPTION	MIN	TYPICAL	MAX	UNIT
Trigger (See note 1)					
$T_{tr}$	Trigger rise time			1	$\mu S$
$T_{th}$	Trigger high time	5			nS
$T_{tl}$	Trigger low time	$3 \times T_{th}$			nS
$T_{bnt}$	Time from busy to next trigger	5			$\mu S$
Busy Output (See notes 2 and 3)					
$T_{bd}$	Busy delay from trigger	15	25		nS
$T_{br}$	Busy output rise time	1	1.5		nS
$T_{bh}$	Busy output high time	45	50		$\mu S$
Gate Output (See note 2)					
$T_{gd,min}$	Minimum gate delay from trigger		25	30	nS
$T_{gd,set}$	Range of settable gate delays	0		100	mS
$T_{gr}$	Gate rise (opening) time 20-80%		.8	1.2	nS
$T_{gh}$	Gate high (opened) time	2		15K	nS
$T_{gf}$	Gate fall (closing) time 20-80%		.8	1.2	nS
Toggle, Last Sample, and Averaged Outputs					
$T_{gct}$	Time from gate close to toggle out	9	10	11	$\mu S$
$T_{gcsv}$	Time from gate close to sample valid		10	12	$\mu S$
$T_{gcac}$	Time from gate close to average change	10	12		$\mu S$
$T_{blav}$	Time from busy low to average valid			0	$\mu S$
<p>Note1: The trigger may be positive or negative. In this specification, 'High' refers to the time over threshold, and 'Low' refers to the time below threshold.</p> <p>Note 2: The output should be terminated into 50<math>\Omega</math>.</p> <p>Note 3: The Busy output high time is specified for sub-microsecond gate delays and widths. This time will be extended if longer gate widths or delays are used.</p>					

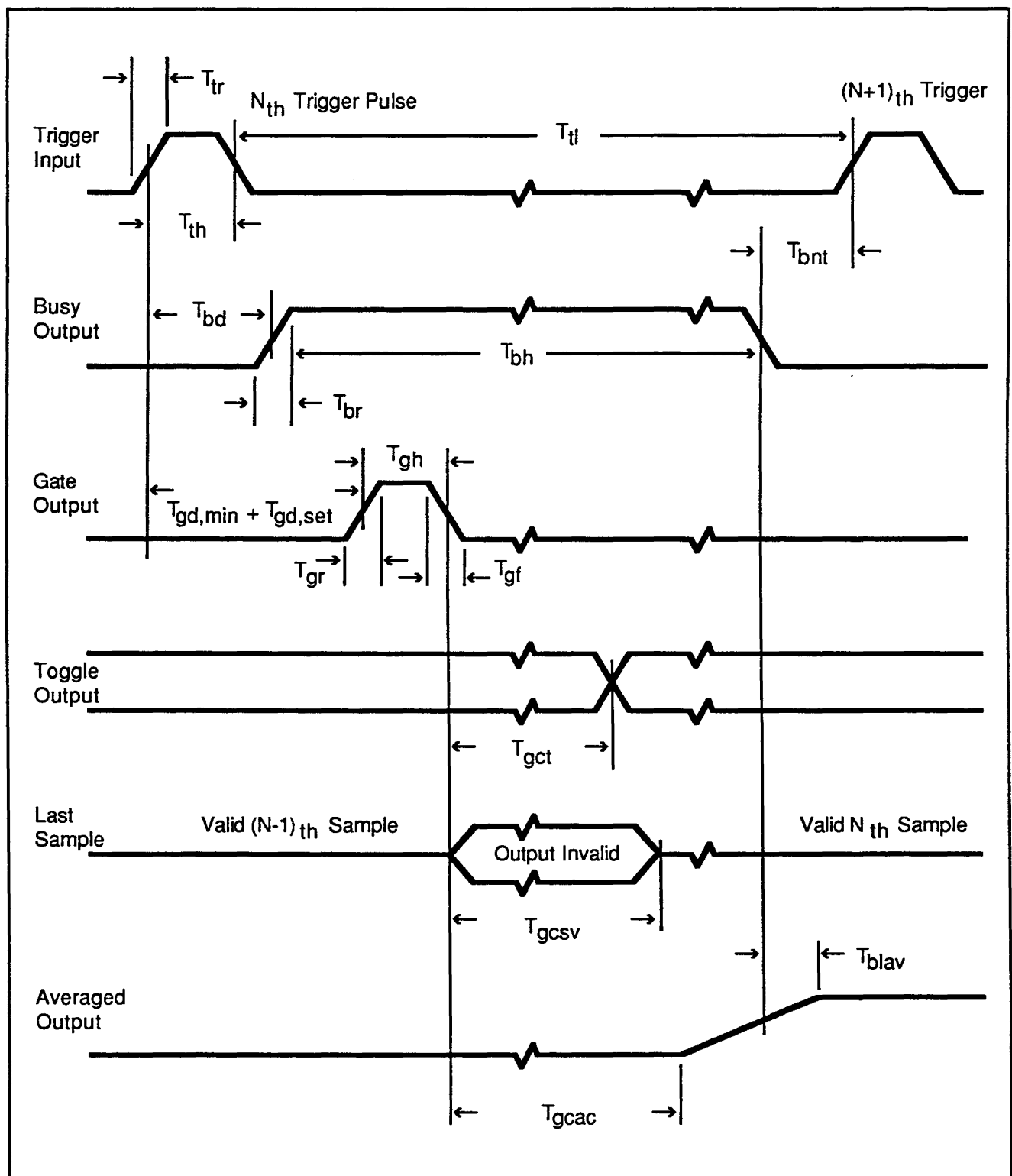


Figure 10 - SR250 Timing Diagram



## TROUBLESHOOTING

Although the SR250 is relatively straightforward to operate, there are a few common problems that users encounter. The troubleshooting suggestions given here are not intended to diagnose a unit failure, rather, they are intended to help the user be sure that the apparent malfunction is not an 'operator error'.

Troubleshooting at the component level is not recommended as there are several pitfalls for the untrained. Factory service is available.

To start, be certain that the unit is screwed into the mainframe, that all four power supplies are okay ( $\pm 12$  and  $\pm 24$  VDC). When measuring the bin supplies, beware of the 110 VAC on the pins at the bottom of the NIM connector block.

### PROBLEM

### PROBABLE CAUSE

No trigger LED on internal trigger ranges

The NIM Bin power supply is off, unplugged, or defective. The Boxcar Module is not plugged in all the way. Bad trigger LED.

External trigger does not work

The trigger threshold is set too high or the external trigger pulse is too small ( $< .5\text{VDC}$ ) or too fast ( $< 5\text{nS}$ ). Also, Q1 or Q2 may be damaged from excessive inputs ( $> 100\text{ VDC}$ ).

Line trigger does not work

The THRESHOLD knob needs to be adjusted, or the NIM neutral is floating (operating off an isolation transformer).

Erratic triggering

Threshold is too high or triggered during the Busy period. If a long delay scale is selected, the unit allows itself more time to reset the delay one-shot which will extend the Busy pulse and reduce the maximum repetition rate.

Gate delay multiplier does not work

Something (such as the Gate Scanner Module) was left plugged into the rear panel EXTERNAL DELAY CONTROL which overrides the delay multiplier.

Cannot see the gate

GATE output not terminated into  $50\Omega$ , oscilloscope improperly triggered, or gate width set below  $2\text{nS}$ .

PROBLEM	PROBABLE CAUSE
Ovrrange LED on	Input Signal > 2VDC or the LAST SAMPLE output is greater than 10VDC. The later may be corrected by adjusting the input offset control or by reducing the sensitivity. If the unit is not triggered, the LAST SAMPLE output drifts at 0.1% per second. Eventually the LAST SAMPLE output may drift to $\pm 10$ VDC and turn on the Overrange LED.
AVERAGED OUTPUT does not work	Check if the rear panel switch AVERAGE POLARITY CONTROL is in the toggle position. Reread the Active Baseline Subtraction explanation. Check if something was left plugged into the rear panel AVERAGE RESET.
Wrong Polarity at LAST SAMPLE or AVERAGED OUTPUT	Check the positions of the rear panel POLARITY CONTROL switches.
Input offset control does not move AVERAGED OUTPUT	In the Active Baseline Subtraction Mode it is not supposed to. All input offsets (and Baselines) are cancelled by the Active Baseline Subtraction circuits.
Choppy output at the AVERAGED OUTPUT	This can happen in the Active Baseline Subtraction mode when averaging just a few shots. The chop can be reduced by averaging over more shots or by adjustment of the input offset control.
Excessive gate jitter	External trigger amplitude is too small or the rise time is too slow. Also, gate jitter is reduced by using the shortest delay scale that will work. Triggering too close to the Busy period (within a few $\mu$ S) may also cause the gate to jitter.
LAST SAMPLE erratic	Input signal noisy or overrange. Sensitivity too high. Excessive trigger amplitude or high frequency noise.

## CALIBRATION

The procedure for recalibrating the SR250 is given in this section. Normally, recalibration is not needed or recommended, however, if the unit has been repaired and components replaced, then this procedure may be required. This procedure should be undertaken only by qualified persons. Factory recalibration is available: please call Stanford Research Systems for details.

This procedure may also be used to carefully verify that a unit is working properly: just follow the procedure without making any adjustments. If any adjustments are made, it is necessary to complete the entire recalibration procedure.

## POWER SUPPLY CHECK

Internally trigger the unit at 3+KHz, and trigger the oscilloscope with the BUSY output. To check for supply oscillation and response, look at each supply on AC 5mV/Div, 50 $\mu$ S/div. Record supply spike amplitudes. Record supply levels using a DVM.

### NIM Supplies [ $\pm 1\%$ ]

Supply	VDC	AC Spike	Osc?
VDC		[<30mV]	Y/N
+24	_____	_____	_____
+12	_____	_____	_____
-12	_____	_____	_____
-24	_____	_____	_____

### Internal Supplies [ $\pm 5\%$ ]

Supply	VDC	AC Spike	Osc?
VDC		[<20mV]	Y/N
+15	_____	_____	_____
+5	_____	_____	_____
-5	_____	_____	_____
-15	_____	_____	_____

## INTERNAL TRIGGER OPERATION

Set-up: Delay= 10nS x 1.0  
 Width= 30nS x 3  
 Signal= 1V, DC, centered offset  
 Average= 300 Samples  
 Polarity= Both Switches up

[ ] Trigger LED Working?  
 [ ] Line Trigger at 60Hz?  
 [ ] Visual Trigger 1-30Hz?  
 [ ] Manual Trigger Working?

Internally Trigger the unit at 1+ KHz. Trigger the scope on the rising edge of the BUSY output. Look at the BUSY output into a 50 $\Omega$  load.

\_\_\_\_\_ V Busy Output Amplitude [1.9V to 2.3V]  
 \_\_\_\_\_  $\mu$ S Busy Output Duration [43 $\mu$ S to 48 $\mu$ S]  
 [ ] Trigger Rate Generator from 100Hz to 20KHz?

## GATE WIDTH CHECK

Internally trigger the unit at 10+ KHz. Trigger the scope on the rising edge of the BUSY output, and observe the GATE output terminated into 50 $\Omega$ .

\_\_\_\_\_ mV GATE output amplitude [180 - 230mv]

Width Scale	Gate Width (mult=5)
3 $\mu$ S	_____ $\mu$ S [ $\pm 30\%$ ]
1 $\mu$ S	_____ nS [ $\pm 30\%$ ]
300nS	_____ nS [ $\pm 30\%$ ]
100nS	_____ nS [ $\pm 30\%$ ]
30 nS	_____ nS [ $\pm 30\%$ ]
10 nS	_____ nS [ $\pm 30\%$ ]
3 nS	_____ nS [ $\pm 30\%$ ]
1 nS	_____ nS [ $\pm 30\%$ ]

**GATE DELAY CALIBRATION**

- [ ] Adjust P13 at location B7 for 10.00VDC at CW mark of P14 @ A7.
- [ ] Adjust P12 at location B5 for 10.1VDC across R54 at location B5.
- [ ] With the delay scale set to 1 $\mu$ S and the delay multiplier at 1.00, adjust P4 at location C5 for 1.00 $\mu$ S from BUSY to GATE.

Measure and record the time from the rising edge of the BUSY output to the start of the GATE output.

Trig	DelayScale	Mult=10.0	Mult=0.0
10K	1 nS	_____ nS	_____ nS
10K	10 nS	_____ nS	_____ nS
10K	100nS	_____ nS	_____ uS
1 K	1 $\mu$ S	_____ $\mu$ S	_____ $\mu$ S
1 K	10 $\mu$ S	_____ $\mu$ S	_____ $\mu$ S
100	100 $\mu$ S	_____ $\mu$ S	_____ mS
100	1 mS	_____ mS	
10	10 mS	_____ mS	

**LAST SAMPLE OUTPUT**

**Setup:** Internal Trigger at 100 Hz  
Width= 3 $\mu$ S x 3  
Delay=10nS x 10.0  
Sensitivity =20 mV

- [ ] Adjust the offset pot to read 0.0 VDC at the LAST SAMPLE output.
- \_\_\_\_ VDC Measurement of voltage on offset pot rear-most lug, V(sw). [<2 VDC]
- \_\_\_\_ VDC Adjust Offset Pot for 5.0VDC at LAST SAMPLE output. Invert last sample output and record last sample output voltage. [-5.00VDC]
- +\_\_\_\_ VDC Last Sample output for positive over-range indicator.[+10 VDC]
- \_\_\_\_ VDC Last Sample Output for negative over-range indicator. [-10 VDC]

**AVERAGED OUTPUT TESTS**

**Setup:** Adjust offset for LAST SAMPLE=5.00VDC.  
Average over 300 samples.  
Trigger at 1+ KHz.

____ VDC	Non-inverted	AVERAGED OUTPUT
	[5.00VDC]	
____ VDC	Inverted	AVERAGED OUTPUT
	[-5.00VDC]	
____ VDC	Toggle	AVERAGED OUTPUT
	[0.0VDC]	

- [ ] Place AVERAGED OUTPUT on scope, display 0-10VDC. Select normal polarity, and using the front panel reset button, verify an approximate 1 second time constant for 9 Trigger Rate/Sample Average pairs (from 1Hz & 1 Sample to 10KHz and 10K Samples)
- [ ] Verify rear panel reset operation by shorting the input to ground.
- [ ] Trigger at 1+ KHz. Average over 3K samples. Adjust input offset for last sample = 0.0VDC. Select TOGGLE for average polarity then adjust P6 at location E5 (3K sample null) so that AVERAGED OUTPUT is 0.0VDC.

**RESET NULL ADJUST**

**Setup:** 1KHz Trigger  
Delay = 10nS x 1.0  
20mV Sensitivity  
Width = 3ns x 3  
Adjust Input Offset for Last Sample = 0V

- [ ] Viewing Pin 6 on the LM318 (U18 at location D2) adjust P8 at location D7 (Reset Null) for the best return to its baseline at a time 50 $\mu$ S after reset.

**GATE RATIO ADJUST**

**Setup:** Trigger at 1KHz  
 Delay =  $10\text{nS} \times 1.0$   
 Average over 300 Samples  
 Width = 300nS Scale  
 Sensitivity = 50mV  
 Input offset for Last Sample = 0.0VDC  
 DC couple  
 Average Output Polarity = Toggle

Use the Toggle output, terminated into  $50\Omega$ , and Via a  $220\Omega$  resistor to the Signal input as the signal source. The Signal Output must be terminated into  $50\Omega$ . Now the Average output is a Baseline Corrected measurement of the instrument's sensitivity.

- [ ] Verify that the signal output is a 320mV square wave.
- [ ] Carefully adjust P5 at location C3 (Gate Ratio) for the smallest change in the AVERAGED output as the Width Multiplier is scanned from 1 to 5. (This adjusts the Gate Width Ratios to 5:1 and so assures that the sensitivity is independent to the Width Multiplier.

**AC AND DC GAIN CALIBRATION**

**Setup:** Trigger External  
 Delay =  $1\mu\text{s}$  scale  
 Sensitivity = .1VDC

Use the SR200 Gate Scanner to scan the delay multipliers from 0 to 10. Use a  $10\mu\text{s}$ , 500mV fast pulse (@3KHz) as the signal input. Place the scope in the XY mode to display the input waveform. The Gate Output from another SR250 will do.

- [ ] Adjust the P9 at location F5 (DC gain) to get a flat top on the observed voltage waveform. This matches the AC and DC gains.
- [ ] Observe about 40% droop of the flat-top when the input filter switch selects 10KHz.
- [ ] Observe a baseline shift when coupling changes from DC to AC.

**SENSITIVITY CALIBRATION**

The instrument's sensitivity is calibrated in this section. With the sensitivity set at 0.2V, a 1.00VDC input should produce a 5.00VDC output.

**Setup:** Trigger 1KHz  
 Delay =  $1\mu\text{s} \times 1.0$   
 Sensitivity = .2VDC  
 Width Multiplier = 3.0  
 Terminate Gate Output in  $50\Omega$

Set the width scale to  $3\mu\text{s}$ . Input 0.00VDC and adjust the input offset to give 0.0VDC at the Last Sample Output. Input 1.00VDC and adjust P7 (Gain) at location F5 to read 5.00VDC at the Last Sample Output.

For each Width Scale in the table below, input 0.00VDC and Adjust the input Offset for Last Sample = 0.0. Then input 1.00VDC and record the voltage at the LAST SAMPLE output.

Width Range	LAST SAMPLE Output
3 $\mu\text{s}$	5.00 VDC [by adjustment]
1 $\mu\text{s}$	___ VDC [5.0V $\pm$ .25V]
300 nS	___ VDC [5.0V $\pm$ .25V]
100 nS	___ VDC [5.0V $\pm$ .25V]
30 nS	___ VDC [5.0V $\pm$ .25V]
10 nS	___ VDC [5.0V $\pm$ .25V]

- [ ] Be certain to terminate the GATE output
- [ ] Adjust C121 at location C1 to calibrate 3nS Width Scale Sensitivity.
- [ ] Adjust P11 at location D2 to calibrate 1nS Width Scale Sensitivity.
- [ ] Adjust P10 at location E3 for maximum flatness of Average Out vs Width Multiplier.

With the Width Multiplier returned to x 3, repeat these adjustments:

- [ ] Adjust C121 at location C1 to calibrate the 3nS Width Scale Sensitivity.
- [ ] Adjust P11 at location D2 to calibrate 1nS Width Scale Sensitivity.

**HIGH SPEED PERFORMANCE**

Return to the X-Y mode to display the Fast input waveform on the scope.

- \_\_\_\_ nS Record the gate width setting for which the sensitivity falls to 50% of its nominal value [about  $2 \times 1\text{nS}$ ].
- \_\_\_\_ nS Record the 20% to 80% rise time of the displayed waveform. [3nS].
- \_\_\_\_ nS Record the 20% to 80% fall time of the displayed waveform. [3nS]

**MODIFICATIONS****INCREASING THE SENSITIVITY**

In situations where pre-amplifiers are not available, the sensitivity of the SR250 may be increased by an approximate factor of 10 by replacing the integrating capacitors with smaller values. The required changes are listed below in Figure 11.

**EXTENDING THE GATE WIDTH**

The SR250 gate width can be extended to  $150\ \mu\text{s}$  with the addition of a  $0.33\ \mu\text{f}$  capacitor. This capacitor is placed in parallel with C127, which controls the width of the gate pulse on the  $3\ \mu\text{s}$  width scale. The capacitor should be soldered to the solder side of the printed circuit board, between the right pad of C126 and the left pad of C127 (as viewed from the component side.) A poly or mylar film capacitor with a 5% tolerance should be used. With this modification, only the  $30\ \mu\text{s}$  width scale is affected, and on this scale:

- 1) The  $3\ \mu\text{s}$  width scale is changed to  $30\ \mu\text{s}$ , allowing gate widths from  $30\ \mu\text{s}$  to  $150\ \mu\text{s}$ .
- 2) The sensitivity is increased by a factor of 10. This is because the gate width was made 10 times longer while the integrating capacitor was left the same. It is not possible to increase the integrating capacitor due to limitations on the reset circuitry.
- 3) The actual gate width depends somewhat on the repetition rate. See Figure 12 for details.

Width Range	Integrating Capacitor	Board Location	Factory Value (pf)	Action to Increase Sensitivity by x10
1 nS	C212	F4	56	Not recommended
3 nS	C219	D1	150	Not recommended
10 nS	C220	D1	1000	Remove C220
30 nS	C221	D2	3300	Replace C221 w/ 220 pf
100 nS	C222	D2	10,000	Replace C222 w/ 1000 pf
300 nS	C223	D2	33,000	Replace C223 w/ 3300 pf
1 $\mu\text{S}$	C224	D2	100,000	Replace C224 w/ 10,000 pf
3 $\mu\text{S}$	C225	C2	330,000	Replace C225 w/ 33,000 pf

Notes:

- 1) Use only silver mica, poly or mylar film capacitors.
- 2) Be careful not to damage the PCB with excessive heat.
- 3) We suggest removing only one lead of the capacitor to be replaced and attaching the new component to the non-component side of the printed circuit board.
- 4) The overload light will not function properly on the 1V/V sensitivity scale.

Figure 11 - Increasing The Sensitivity By A Factor Of 10

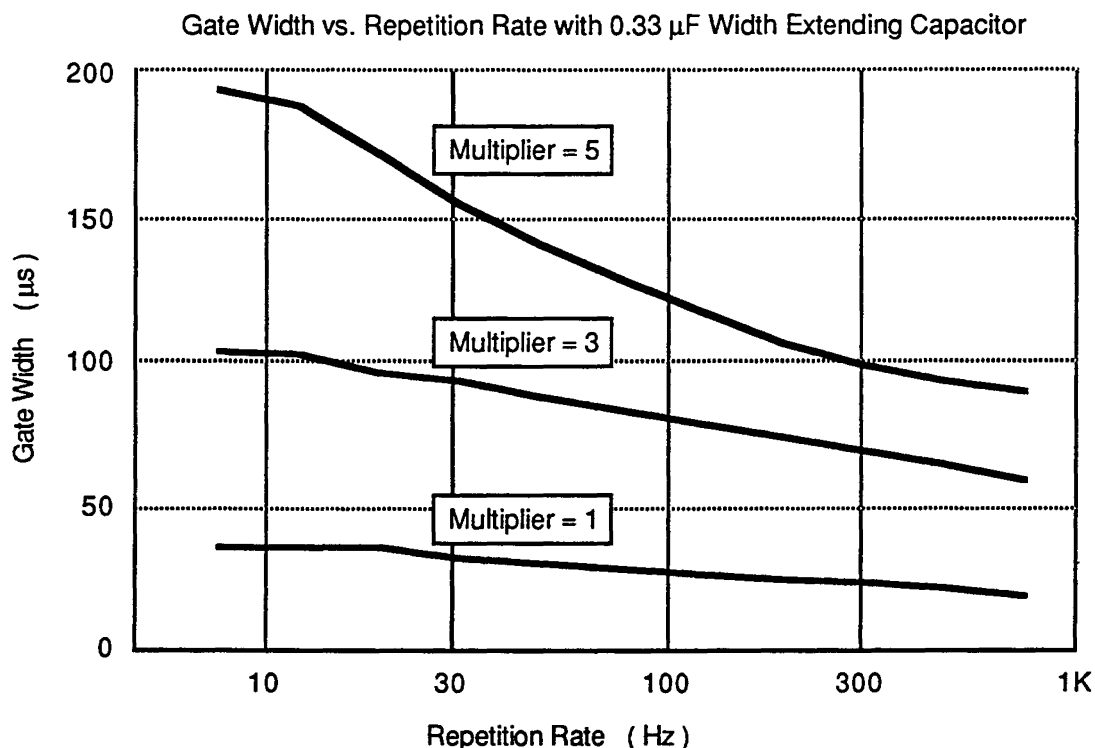


Figure 12 - Gate Width vs. Repetition Rate After Gate Width Modification

- 4) The gate marker output will have some droop. This does not affect the operation of the device: its response is flat during the gate.
- 5) Beware of using the 10KHz input filter. This filter AC couples input signals with a 15  $\mu$ s time constant.

#### REPLACING FRONT END TRANSISTOR

Symptoms: The red OVER RANGE LED stays on and the LAST SAMPLE output cannot be zeroed.

Supporting Evidence: Your photomultiplier anode does not have a leakage resistor, and so is prone

to charging up the signal cable to a few hundred volts. The last time you saw the red light off was just before you plugged the cable into the signal input.

Conclusion: The front end transistor, Q20, a J310 N-Channel JFET, is damaged.

Replacement: Q20 is at location G2 on the printed circuit board. Before removing the damaged Q20, note its orientation: the silk screen legend on the circuit board is wrong. The new J310 must go in opposite to the legend, the same as the old J310. No recalibration is required when replacing Q20.

## CIRCUIT DESCRIPTION

The SR250 Gated Integrator and Boxcar Averager Module is constructed on a single printed circuit board, mounted in a NIM compatible module. The unit uses about 12 Watts of power from the 12 and 24 volt NIM supplies. All critical circuits use doubly regulated supplies: the NIM  $\pm 24V$  supplies are regulated to  $\pm 15V$  and the  $\pm 12V$  supplies are regulated to  $\pm 5V$ . RF performance is enhanced by use of PCB mounted rotary switches, careful design of the PCB, and by the use of some very fast transistors in emitter coupled configurations. Reliability is assured by careful design and manufacturing, and by comprehensive testing and burn-in of every unit.

### TRIGGER CIRCUIT

The trigger input has a  $1M\Omega$  input impedance. The trigger input is buffered by transistors Q1 and Q2 which drive a  $100\Omega$  stripline going to the trigger discriminator, U1. If the trigger exceeds the trigger threshold, U1 clocks the trigger latch Q3-Q6, turning on the constant current source for the delay one-shot. The trigger latch will be reset after the sample gate is finished, and is disabled until the unit is ready to receive another trigger.

### DELAY ONE-SHOT

The delay capacitor, which was precharged to a specific voltage by the Delay Precharge circuit, is discharged by the constant current source,  $1/2$  U4. The value of the delay capacitor increases by 10. The precharge voltage depends on the delay multiplier setting (or on the External Delay Control Voltage, if used). When the delay capacitor is discharged to about 5V, the End Of Delay discriminator sets the End of Delay latch. The latch output is buffered by Q12 and Q13 and delayed by two coax delay lines. The delayed signal is received by Q14 and Q15 which start the gate. The delay lines delay the start of the gate by a few nS, cancelling the insertion delay of the width one-shot, allowing the generation of very short gates.

### WIDTH ONE-SHOT

The width one-shot is similar to the delay one-shot. A constant current source,  $1/2$  U5, is turned on at the end of the delay one-shot. A width capacitor, selected by the WIDTH SCALE selector, is precharged to a voltage determined by the Width Multiplier control pot. When the width capacitor is discharged to about 5V Q16, Q17, and  $2/2$  U5 latch-up, indicating the End Of Gate. This End Of Gate is used to turn off the gate at U6.

### GATE BUFFER

U6 consists of two emitter coupled pairs with constant current sources, which are configured as an exclusive-or gate. The output of U6 is used to drive the bases of Q29 and Q30, very fast (4GHz) transistors, which gate open the high speed analog gated integrator. Part of the collector current of transistor Q29 is passed out via the GATE front panel connector. This output must always be terminated into a  $50\Omega$  load for proper operation of the instrument.

### SIGNAL INPUT AND OUTPUT

The SIGNAL input is passed to the SIGNAL OUTPUT via  $3.5nS$  of coax cable. This delay is inserted so that there will be an exact coincidence between the SIGNAL OUTPUT and the GATE output to allow simple, accurate set up of the instrument. The SIGNAL input is coupled directly, or via a  $.01\mu F$  capacitor, to a  $1M\Omega$  input impedance unity gain buffer amplifier, Q20 and Q21. The input signal is also passed to an IC op amp circuit. The op amp output will be used in a feedback loop to eliminate DC drifts associated with the fast buffer amplifier and gated integrator.

### GATED INTEGRATOR

The Fast Gated Integrator consists of transistors Q23-Q28 and their associated bias circuits. Q23 and Q28 are constant current sources that are 'programmed' by the input signal: for a positive input signal the current in Q23 is reduced and the



current in Q28 is increased. This current imbalance is integrated on the integrating capacitor when the gate is opened. A difference amplifier, 3/4 of U16, compares the imbalance to the input signal and makes minor adjustments to the current sources to eliminate drift. The low frequency gain of the gated integrator is set by P9 to match the high frequency gain (determined by the emitter resistors of Q23 and Q28) to produce a flat response from DC to over 100MHz. The analog current gate, Q24-Q27, normally channels the current imbalance to ground. When the gate drive is applied to the gated integrator, Q24 and Q27 turn off, and Q25 and Q26 turn on, channelling the current imbalance to the integrating capacitor. The integrating capacitor, which was reset prior to the unit being triggered, integrates the current imbalance while the gate is open. The value of the integrating capacitor changes with the WIDTH SCALE: bigger integrating capacitors are needed for longer gates in order to avoid saturation. When the gate turns off, the voltage on the integrating capacitor is proportional to the integral of the input signal during the gate.

#### GATE WIDTH NORMALIZATION

We want a result from the gated integrator which is proportional to the average of the input signal during the gate, not to the integral of the input signal. To accomplish this, we must divide the integral of the signal by the gate width. This is done in two ways. First, as the WIDTH SCALE is changed, the width selector switch changes both the width one-shot capacitor and the integrating capacitor. The ratio of these capacitors is carefully matched on all width ranges by selecting width compensating capacitors after the unit is burned in at the factory. Secondly, the gated integrator output is normalized for the width multipliers within a particular range. This is done by using a dual pot for the width multiplier: one of the pot elements is used to change the width of the gate, while the other is used to scale the gain of 3/4 U17. By decreasing the gain for wider gates the integral is normalized becoming an average.

#### SENSITIVITY

The sensitivity of the unit is changed by changing the gain of U18 which amplifies the output of the gated integrator. This amplifier has a switch selectable gain from 0.5 to 100. The Offset Control is injected before U18, so that the offset is also amplified, making it appear as an input offset (as opposed to a position) control.

#### SLOW LOGIC TIMING

At the end of a sample gate, a TTL signal, 'END', is generated to start a 10 $\mu$ S one-shot, 1/2 U15. This 10 $\mu$ S signal is used to sample the gated integrator output. When finished, the 10 $\mu$ S SAMPLE pulse re-triggers the 10mS one-shot, 2/2 U15, to blink the TRIG LED, and toggles the flip-flop that is used for active baseline subtraction. 'END' is also used to reset the trigger latch. Upon reset, the trigger latch clocks the one-shot 1/2 U8, initiating a pulse which is at least 12 $\mu$ S long in order to reset the Gate Delay Circuit. This pulse, 'R-DELAY', is extended in order to allow the delay capacitor time to precharge if the unit is using a delay range greater than 100nS. When 'R-DELAY' ends, 2/2 U8 is triggered, starting a 33 $\mu$ S pulse which is used to (1) Precharge the width one-shot timing capacitors, (2) reset the Gated Integrator capacitors, and (3), add the Last Sample to the Boxcar Average. After the 33 $\mu$ S one-shot times out, the cycle is complete, and the BUSY output, which has been high during the entire cycle, is released. When the BUSY is released, the trigger inhibit is also removed, allowing the next trigger to occur.

#### OVER RANGE LED

The OVER RANGE LED is turned on when the input signal exceeds  $\pm 2$ VDC, or, if the LAST SAMPLE output exceeds 10VDC. In the first case, the input signal must be reduced, or the coupling changed to an AC range. In the second case, the overrange error may be eliminated by either reducing the SENSITIVITY or by adjusting the INPUT OFFSET control.

## INTRODUCTION

The model SR255 Fast Sampler is a high speed, sample and hold module designed to measure signals of very short time duration.

The SR255 consists of a trigger discriminator, delay generator, gating circuit, sampling bridge, and digital linearization circuit. A voltage applied to the rear panel BNC controls the delay between the

trigger and the sample gate. The gating circuit activates the sampling bridge with a pulse generated by a step recovery diode and a shorted transmission line. The line's round trip delay is set internally to provide a gate width of 100 psec, 200 psec, 500 psec or 1 nsec. The sampled voltage is amplified according to the front panel SENSITIVITY switch, and digitized by an 8 bit A/D converter. The digitized signal is adjusted by a PROM which is customized for each unit to linearize the response

## SPECIFICATIONS

### GATE WIDTH

100 psec, 200 psec, 500 psec, and 1 nsec.  
Front panel LED indicates selection.

### CONTROLS

#### Sensitivity

100mV/V, 250 mV/V, and 1 V/V (Vin/Vout).  
Overrange LED indicates signal is too large.

#### Trigger Level

-0.5 V for negative trigger (NIM standard).  
+0.1 V for low level positive triggers.  
+1.0 V for TTL compatibility.  
LED blinks with each trigger. 50 KHz max rate.

### INPUTS

#### Signal Input

Protected to +5 VDC.  $Z_0 = 50 \Omega$ .

#### Trigger Input

Full Scale input equals the sensitivity setting.  
Protected to +5 VDC.  $Z_0 = 50 \Omega$ .

#### Gate Delay

1 nsec/V, 10 nsec/V, 100 nsec/V, or 1  $\mu$ sec/V.  
Input at rear panel. Minimum insertion delay is 20 nS.  
Jitter less than 10 psec +.01% of full scale delay.

### OUTPUTS

#### Signal Output

SIGNAL IN is passed to SIGNAL OUT for termination, signal timing and special applications.

#### Gate View

The leading edge shows precise timing of the sample gate with respect to SIGNAL OUT

#### Sample Output

Provides an analog output (without droop) of the sampled signal. Output resolution is 1/4% of full scale.

#### Digital Output

8-Bit digital interface for the SR245 or a computer.

Data Byte - 8 bits give the amplitude of the signal sample including PROM linearity correction.

Status Byte - provides status of gate width, sensitivity, data ready, data sign, data missed, and overload error.

### GENERAL

#### Power

+24V / 100 mA, -24V / 110 mA, +12V / 150 mA, -12V / 35 mA ,  
7.5 Watts total. Power from Model SR280 Mainframe or from a NIM Standard Crate .

#### Mechanical

Single width NIM Standard per TID-20893.  
Dimensions 1.35" x 8.714" x 11.5".

#### Warranty

One year parts and labor. This warranty does not cover damage to the sampling bridge by excessive input.

Figure 13 - SR255 Front Panel

of the sampling bridge. The adjusted digital signal is output via a rear panel connector. A D/A converter provides a droopless analog output signal at the front panel SAMPLE OUT BNC.

## OPERATION

This section describes the operation of the SR255 Fast Sampler including the controls and input/output characteristics.

### TRIGGER

The module is triggered by a signal at the 50  $\Omega$ , DC coupled, trigger input. The trigger threshold may be set to -0.5 V, +0.1 V, or +1 V by the TRIGGER LEVEL switch on the front panel. For reliable triggering, the trigger must remain over threshold for at least 5 nsec, and not exceed 5 volts. The maximum trigger rate is 50 kHz (reduced when operating on the 1  $\mu$ sec delay scale.) A green LED on the front panel flashes with each trigger.

### DELAY

The delay from trigger to sample is controlled by an analog voltage which is applied at the rear of the unit. Apply 0 to 10 VDC to move the sample gate from 0 to  $\times 10$  the selected time base scale. The time base is selected by a bank of four switches on the PCB. You may select 1, 10, 100, or 1000 nS/V. These switches may be accessed through the right side panel. In addition to the controlled delay, there is a fixed insertion delay of about 20 nS.

### WIDTH

The width of the sample gate is set by three items on two circuit boards:

- 1) The shorting screw on the RF circuit board's transmission line.
- 2) A switch bank on the RF circuit board.
- 3) A switch bank on the main board adjacent to the switch bank on the RF circuit board.

The unit is shipped configured for a 100 psec gate width. To change the gate width:

- 1) Move the transmission shorting screw from its position closest to the input to the hole

corresponding to the desired gate width.

- 2) Move the RF board switch for 100 psec to OFF and move the RF board switch corresponding to the desired gate width to ON.
- 3) Move the main board switch for 100 psec to OFF and move the main board switch corresponding to the desired gate width to ON.

Both switches and the screw must be in their correct positions for proper operation of the module. When power is applied, the LED corresponding to the desired gate width will light up.

### SIGNAL IN

The signal to be sampled is applied to the signal input. The system is designed to be used with RG58A cable. To achieve an optimally flat response, use two meters of RG58A cable with a BNC connector, and a BNC to N-Type converter (part #UG 201A/U, provided with each SR255.) The frequency response of the SR255's front end has been peaked above 2 GHz to compensate for the losses in 2 meters of RG58A cable, and so you will get the best results when using this length of cable on the signal input line. This input is passed to SIGNAL OUT via an internal 300 psec delay line. The signal output should be terminated in 50 $\Omega$  with a high quality terminator to minimize reflections and pulse distortion. If one is not available, an N-type to BNC converter plus a few meters of RG58-A cable terminated with a barrel and a 50  $\Omega$  BNC terminator will work fairly well. The signal output aids in synchronizing the sample with the gate and can be used for special applications such as time domain reflectometry or shorted-cable baseline subtraction. The input signal should not exceed the SENSITIVITY selection on the front panel. Above this value, the output saturates and the red OVER LED will come on. The input is protected to +5 VDC. Do NOT exceed these voltage limits as repair of the front end is expensive.

### GATE VIEW AND FAST TIMING

To time the Sample Gate with respect to the Signal use equal length cables to bring the GATE VIEW and SIGNAL OUT to the 50 $\Omega$  inputs of a 300 MHz oscilloscope. The GATE VIEW must always see a 50 $\Omega$  termination, so when you complete this operation, do not leave the GATE VIEW

unterminated. The oscilloscope's finite bandwidth will make accurate timing more difficult than is necessary: the leading edge of the GATE VIEW output indicates when the sample gate is being opened. The GATE VIEW output is a pulse of approximately 3 Volt amplitude, 50pS rise time, with an exponential decay of about 4 nsec.

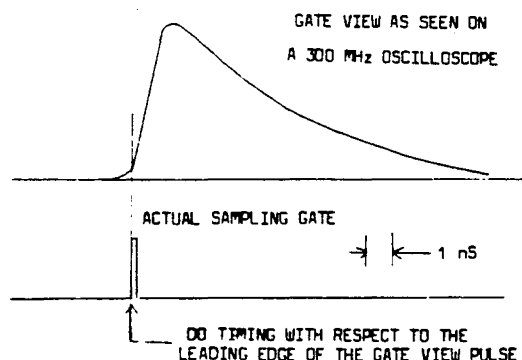


Figure 14 - Gate View

## SENSITIVITY

The SENSITIVITY switch selects the gain of the module, volts in / volts out. It can be set to 1 V/V, 0.25 V/V, or 0.1 V/V. For example, a 100 mV input will cause a 1 V output when 0.1 V/V sensitivity is selected. The red OVER LED will come on when the output exceeds approximately 1 volt.

## SAMPLE OUT

The analog sample output is derived from the 8 bit digital word representing the amplified sampled signal. Its full range scale is +1 VDC and can drive loads greater than 1 K $\Omega$ . The output impedance is less than 1 $\Omega$  and has a short circuit current limit of 20 mA. The output is available 20  $\mu$ sec after the signal is sampled. Each unit is custom linearized with a PROM to insure excellent linearity and full dynamic range.

## BANDWIDTH

The Fast Sampler can be used as a sampling oscilloscope by slowly scanning the gate delay in order to recover a repetitive waveform. The apparent rise time of a infinitely fast step is approximately equal to the selected gate width.

The -3 dB bandwidth of the unit is approximately equal to 0.35 divided by the selected gate width. The table below gives the available gate widths and their corresponding bandwidths.

<u>Gate Width</u>	<u>Bandwidth</u>
1000 pS	359 MHz
500 pS	700 MHz
200 pS	1.7 GHz
100 pS	3.5 GHz

Figure 15 shows an apparent risetime of 150 pS. This curve was taken with a 100pS risetime input step, so the indicated gate width is 110pS. (The apparent risetime is the convolution of the fast sampler gate width with the input signal's rise time.)

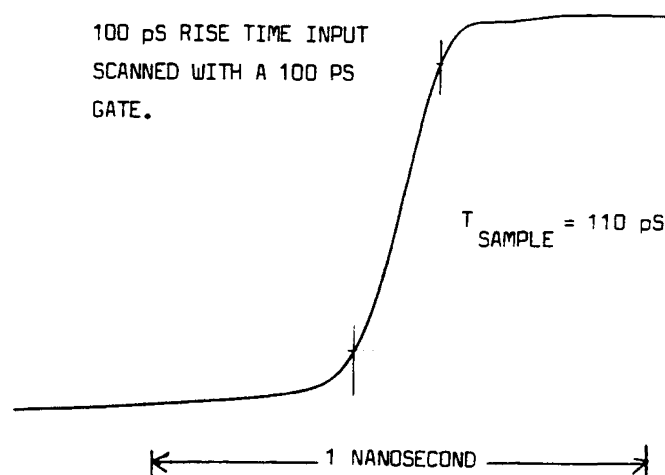


Figure 15 - 100 pS Risetime Input

## NOISE

The penalty paid for using narrow gate widths is increased noise. Narrow gates have more noise because of their reduced sampling efficiency and wider bandwidth. Typical noise characteristics are given in the table below:

<u>Gate Width</u>	<u>Peak to Peak Noise</u>	<u>RMSNoise</u>
1000 pS	1.0 mV	200 $\mu$ V
500 pS	1.8 mV	350 $\mu$ V
200 pS	3.0 mV	600 $\mu$ V
100 pS	4.0 mV	800 $\mu$ V

Figure 16 shows base line noise over a 30 minute period for the four different gate widths. The unit was triggered at 1 Hz. The top curve, taken with a 1 nS gate, shows a noise which is approximately equal to the unit's resolution. The noise increases as the gate width is narrowed.

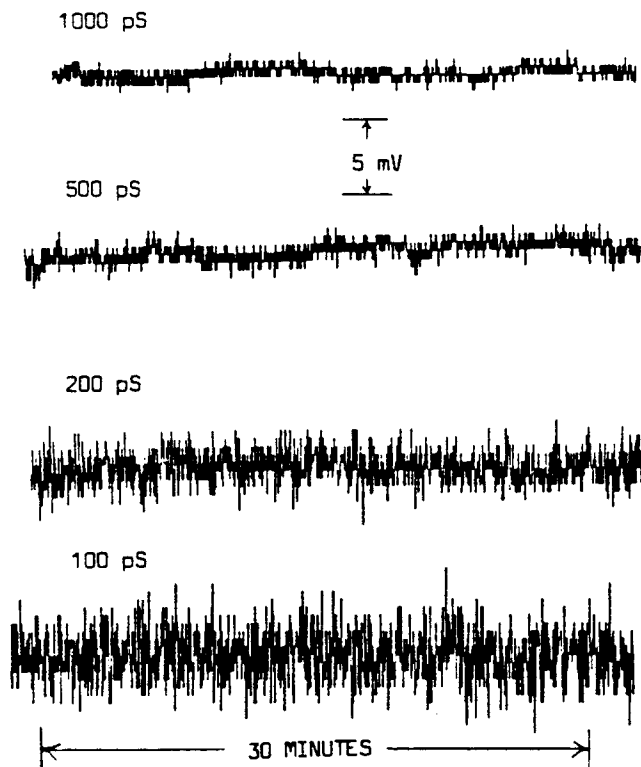


Figure 16 - Noise Characteristics

### REPETITION RATE LIMITATIONS

The unit requires about 19  $\mu$ S to trigger, sample, convert, linearize, and rearm. Some additional time after rearming is required to allow the delay circuit to recharge. This additional time depends on the selected time base delay range. The table below lists the maximum repetition rate before a 1% time base error occurs. Note that for applications which do not require an accurately calibrated time delay that the unit may be triggered at higher rates than are indicated in the table.

Delay Base Range	Maximum Repetition Rate
1 nS/V	50 KHz
10 nS/V	30 KHz
100 nS/V	8 KHz
1000 nS/V	1 KHz

### TEMPERATURE EFFECTS

Both the input offset voltage drift and the gain drift will cause less than a one bit (1/4%) error over ambient temperatures of 20 to 60 degrees centigrade.

### LINEARITY AND RESOLUTION

The unit uses an A/D converter with 9 bits of resolution (8 bits plus sign bit). About 400 of the A/D's 512 output codes are used to cover the full scale input range. This implies a resolution of 1/4 of one percent. The linearity is held to within 1/2 of one percent by the unit's PROM lookup table. The linearization requires that some of the output codes from the PROM be used twice (to compress a signal) or be skipped (to expand a signal). Generally, fewer than 5% of the output codes are skipped or duplicated. Since the input noise usually exceeds the resolution, these missing codes do not degrade the instrument's performance.

Figure 17 shows the high linearity of the instrument's transfer function. The input was scanned over 120% of the full scale input range.

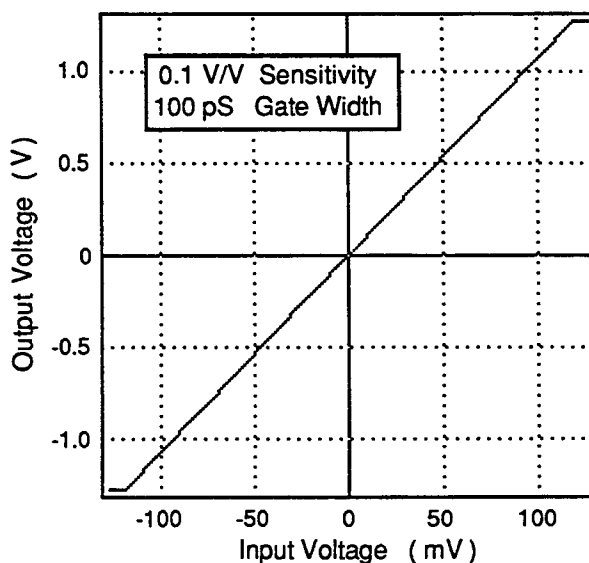


Figure 17 - Linearity

## COMPUTER INTERFACE

The recommended way to interface the Fast Sampler to computers is by connecting the SR255's to an analog I/O port of the SR245 Computer Interface Module. The Fast Sampler is also designed to connect directly to the SR245 through a 15 pin connector on the rear panel of the SR255 and a 20 pin connector on the circuit board of the SR245 (Figure 19). Each Fast Sampler in your system is assigned an address by setting four address switches which may be accessed through the right side panel. Even addresses from 0 to 30 may be selected.

The Status byte and Data byte may be read by the SC<Fn>:x and SS<Fn>:x commands where n is the set address divided by two and x is the number of points to be retrieved. An example SR245 command is SC1,3,F2:100. This command scans ports 1 and 3 and a Fast Sampler with address 4 (see the SR245 manual for definitions of the SC, and SS commands.) A single Fast Sampler Status byte can be retrieved by addressing the module with SD=<y> where y is the set address. Then a ?D will return the status byte. Similarly, a Data byte can be retrieved with y equal to the set address plus 1. Now a ?D will return the data byte.

There is a 15 pin connector on the rear of the SR255 which provides a digital interface to the SR245. This connector has 6 digital inputs, 8 digital outputs, and a common ground line (Figure 18.) The incoming lines serve as module address lines and the out-going lines are tri-state outputs and so several modules may be daisy-chained together over the same digital bus.

The interface is a parallel binary interface which may be connected to either an SR245 computer interface module or to an 8 bit digital I/O port of a computer.

To interrogate the SR255 through the digital interface you must supply the 5 bits of address (A0 to A4) and assert the RD strobe. The least significant address bit selects the Status Byte when low, or selects the Date Byte when high. The Status or Data bytes are placed on the 8 output lines (B0 to B7) when the module is addressed and the RD strobe is asserted low.

The Status Byte is placed on the digital I/O bus by U408 when (1) the module is addressed (A1 to A4 match the switch settings) and (2) both A0 and the RD strobe are low.

Designation	Description	Pin	I/O
B7	Bit 7 of Digital Output (MSB)	13	O
B6	Bit 6 of Digital Output	5	O
B5	Bit 5 of Digital Output	12	O
B4	Bit 4 of Digital Output	4	O
B3	Bit 3 of Digital Output	11	O
B2	Bit 2 of Digital Output	3	O
B1	Bit 1 of Digital Output	10	O
B0	Bit 0 of Digital Output (LSB)	2	O
A4	Bit 4 of Module Address (MSB)	8	I
A3	Bit 3 of Module Address	15	I
A2	Bit 2 of Module Address	7	I
A1	Bit 1 of Module Address	14	I
A0	Bit 0 of Module Address (LSB)	6	I
RD	Read Strobe, Active Low	9	I
GND	Common Ground	1	n/a

Figure 18 - Digital I/O Connector Pin Assignment Table

The MSB of the Status byte, the Data Ready Flag, is set on the trailing edge of the module's END strobe. The Data Ready Flag is reset when the data byte is read. If a second END strobe is detected before or during the reading of the data byte, then the Data Missed Flag, S6, will be set. The Data Missed Flag is reset after the status byte is read.

#### STATUS BYTE DEFINITION

Bit	Definition	(positive logic)	
S7	Data Ready Flag (cleared by a Data read)		
S6	Data Missed Flag (cleared by a Status read)		
S5	Overrange Error		
S4	Sign bit	(1=positive input signal)	
S3	<u>Width</u>	<u>S3</u>	<u>S2</u>
S2	1000 pS	1	1
	500 pS	1	0
	200 pS	0	1
	100 pS	0	0
S1	<u>Sensitivity</u>	<u>S1</u>	<u>S0</u>
S0	1.0 V/V	0	1
	0.25 V/V	1	1
	0.10 V/V	1	0

The six least significant bits of the Status Byte are latched on the rising edge of the Data Ready Flag. These bits represent the state of the module at the completion of the conversion cycle which first set the Data Ready Flag. Because this data is latched, another trigger will only set the Missed Data Flag, and will have no affect on the other status bits or the data byte. The status and data bytes must be read before a trigger if data and status from that trigger event will be needed.

The data Byte is placed on the digital I/O bus by U409 when (1) the module is addressed (A1 to A4 match the switch settings), (2) A0, the LSB of the address is high, and (3) the RD strobe is asserted to its active low state.

#### DATE BYTE DEFINITION

Bit	Description
D7	MSB of the unsigned Data
D6	
D5	(The sign of the data is bit
D4	S4 of the Status Byte.)
D3	
D2	
D1	
D0	LSB of the unsigned Data

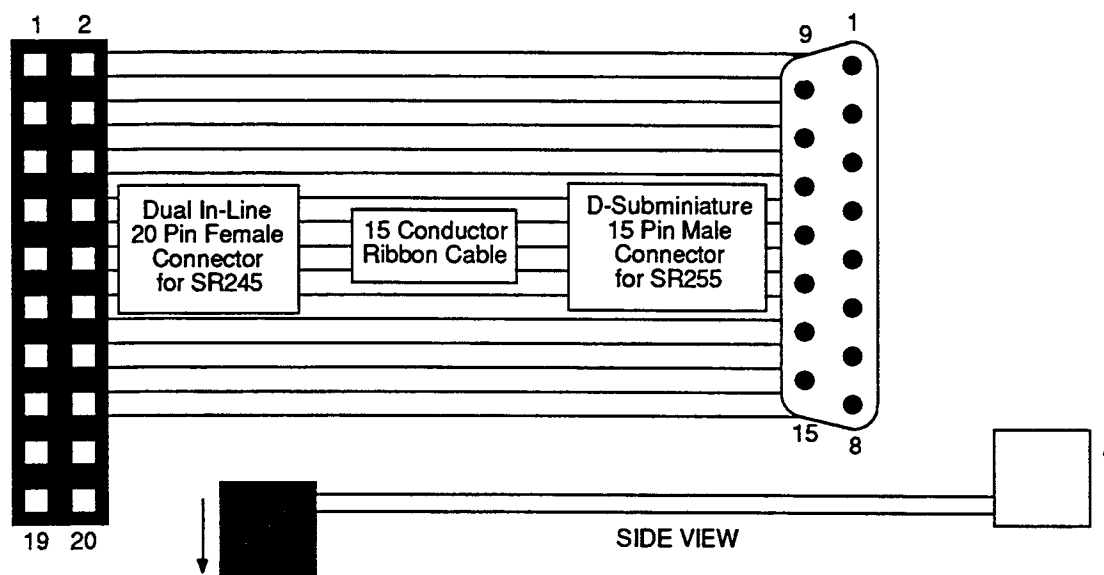


Figure 19 - Connector Assembly For SR245/SR255 Digital Interface

## SAMPLING SCOPE EXAMPLE

The SR255 Fast Sampler can be used in conjunction with the SR200 Gate Scanner and an X-Y oscilloscope to provide sampling scope operation. Resolution of 100 psec can be achieved with sample rates up to 50,000 samples per second.

An interconnect diagram is shown in Figure 20. The SR200 Gate Scanner is used to scan the gate delay over 0 to x10 of the selected delay scale. This scale is set on the SR255 circuit board at 1 nsec, 10 nsec, 100 nsec, or 1  $\mu$ sec to provide time-bases with delays of up to 10  $\mu$ sec. The maximum delay can be extended by the user by increasing capacitor C115 of the 1  $\mu$ sec delay scale. The X-AXIS OUT of the SR200 is used to drive the horizontal X-axis of the oscilloscope. The

PEN LIFT OUT may be connected to the oscilloscope to blank the CRT during retrace.

Finally, the SAMPLE OUT of the SR255 Fast Sampler connects to the vertical Y-axis of the oscilloscope to display the sampled signal. The resolution can be changed by changing the Gate Width of the SR255 (100 psec, 200 psec, 500 psec, 1 nsec.)

An alternative approach is to substitute the SR245 Computer Interface for the SR200 in the above example. The A command will generate a ramp on port 8 which can scan any portion of the delay range. The sampled output may be read through the digital ribbon cable between the SR245 and the SR255, and the sampling scope data may be displayed on your computer screen.

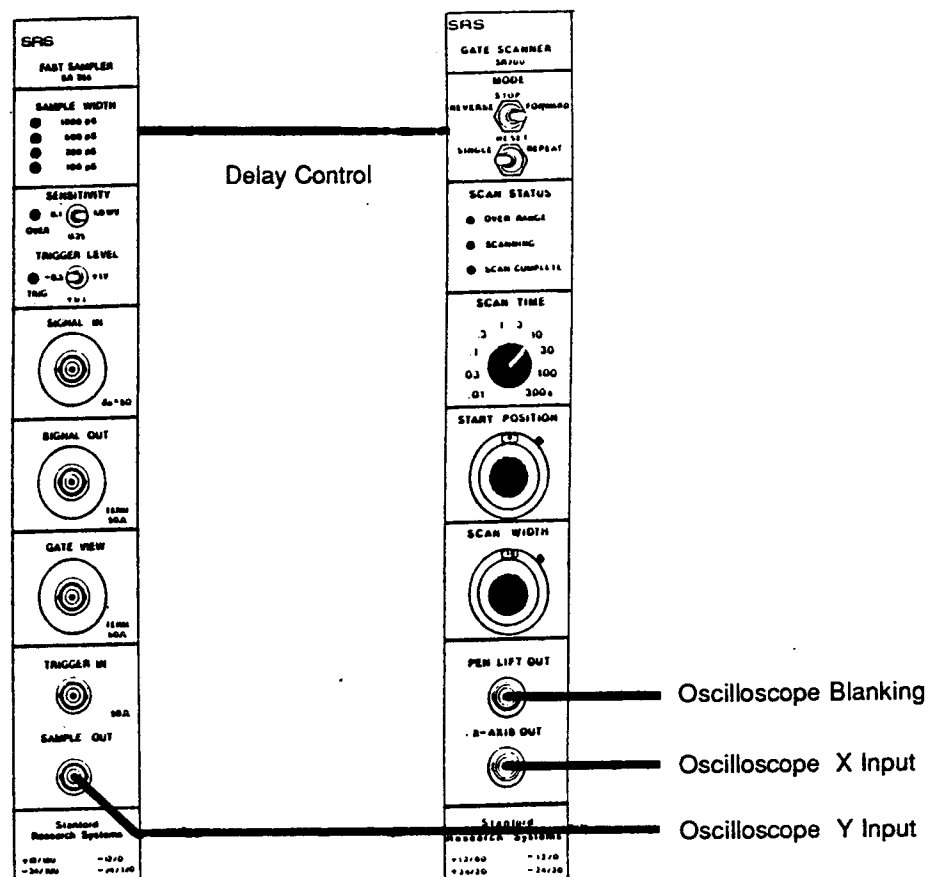


Figure 20 - Setup For Sampling Scope Example



## TROUBLESHOOTING

First, make sure that the module is plugged all the way into the NIM crate with both side panels screwed down, and the NIM crate turned on. Check to make sure that the crate is providing  $\pm 12$  and  $\pm 24$  VDC,  $\pm 2\%$ , with a ripple of less than 20 mV.

### SAMPLING BRIDGE CHECK-OUT

To check if the front end sampling bridge has been damaged, unplug all cables and terminators from the SIGNAL IN, SIGNAL OUT, and TRIGGER IN front panel connectors. Use a battery operated, hand-held digital multimeter to measure the voltage present on the center conductor of the

SIGNAL IN front panel connector. Be certain that the DVM is set to measure volts. If you set the DVM to measure  $\Omega$ , the DC bias supplied by the meter may damage the front end of the SR255. You should measure less than 10 mV on the SIGNAL IN connector. The unterminated DC input impedance of the SR255 is 10 K $\Omega$ , so 10 mV would indicate 1  $\mu$ A of leakage current from the sampling bridge, which is excessive. The sampling diodes become leaky when subjected to an excessive input signal.

A damaged front end must be repaired at the factory. The sampling bridge must be replaced, the GAIN and OFFSET pots and blow-by compensation circuits must be re-calibrated, and new linearization tables must be entered into the unit's PROM. Contact the factory for details.

#### Problem

#### Possible Cause

Overrange LED  
Stays ON

- Unit is not being triggered.
- Input voltage exceeds full scale sensitivity.
- OFFSET pot for selected gate is not adjusted.
- Switches and screw for selected gate width are not set consistently.
- Sampling bridge is damaged (see above.)

No Trigger LED

- Trigger rate is too fast.
- Trigger signal is too small, or wrong polarity.
- Trigger signal duty cycle is too high (Time over threshold > time beneath threshold.)
- External Delay Control Voltage is negative.
- Intercept pot, P101, is far out of calibration.
- Trigger discriminator, U105, has been damaged.

Sample Output  
Is Out Of Calibration

- GAIN or OFFSET pot for selected gate width needs adjustment (see calibration procedure.)
- Load too heavy. SAMPLE OUT should not be terminated into 50 $\Omega$ .
- Switches and screw for gate width selection are not set consistently, or screw is not tight.
- Sampling bridge is damaged (see above.)

## CALIBRATION

### SENSITIVITY AND OFFSET

The object is to calibrate the gain and null the offset for each of the four gate width settings. When very precise measurements are required, the offset may be adjusted each time the gate width is changed. You may also wish to periodically re-calibrate all of the gains. These adjustments must be made with the side panels in place and screwed down. Throughout this procedure, be sure that there is at least one meter of cable attached to both the SIGNAL IN and the SIGNAL OUT front panel connectors. These cables do not have to be terminated into 50Ω, however the GATE VIEW output must be terminated into 50Ω. Failing

to do this will cause the instrument to see a reflected portion of the sampling bridge's kickout signal and so degrade the calibration.

First, select the gate width to be calibrated by moving the shorting screw to the desired gate width, and set both sets of SAMPLE WIDTH switches to the correct positions. ( Only 1 of the four switches in each switch bank is set to on). Install the side panels and their retaining screws. Apply a 1 KHz external trigger and adjust the OFFSET pot corresponding to the selected gate width to null the Sample Output on the 0.1 V/V sensitivity scale. If this cannot be done, see the troubleshooting section for a test to check for damage of the sampling bridge.

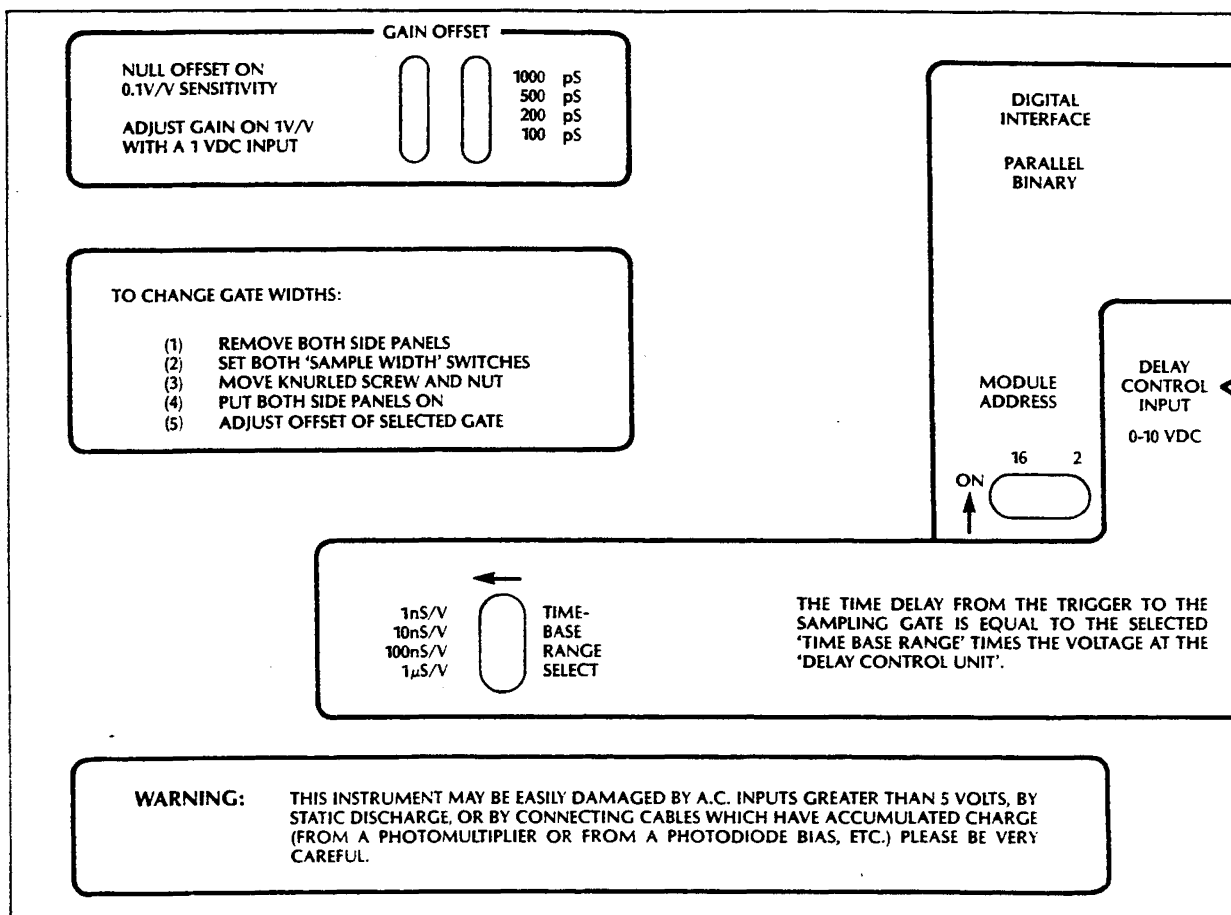


Figure 21 - SR255 Side Panel

To calibrate the gain, select the 1V/V sensitivity scale and apply 1.00 VDC to the signal input. Adjust the GAIN pot for the selected gate width to measure 1.00 VDC at SAMPLE OUT. Repeat this procedure for each of the four gate width settings.

## DELAY CIRCUITS

To re-calibrate the delay circuits remove the right side panel of the module before plugging into the NIM crate. Select the 100 nS/V timebase range by turning on the third switch in the Delay Select switch bank. The three other switches in this bank should be off. With no input connected to the DELAY CONTROL INPUT, observe the position of the Gate View pulse with respect to a 1 KHz external trigger. Adjust P101, the Intercept pot, so that the Gate View pulse is about 10nS from its minimum delay position. This sets the intercept of the Time Delay vs. Delay Control Voltage.

Now select the 10 nS/V timebase range and adjust P102, the Slope pot, so that the Gate View pulse moves by 100 nS when the Delay Control Voltage is scanned from 0 to 10 VDC.

## BLOW-BY CALIBRATION

To compensate the unit for sampling bridge blow-by you will need a signal source to provide a 1 volt 500 nS pulse into 50 $\Omega$ . The signal should have a -0.5 VDC offset, so that the pulse goes from -.5 V to +.5 V. The source must also have a sync output to trigger the SR255 a few hundred nanoseconds before its output pulse.

The object of the blow-by compensation is to use the SR255 in a sampling scope mode of operation in order to get the best representation of the input

signal. To set up, see section 5 of this manual which uses an SR200 Gate Scanner to scan the gate over a 1000 nS range. The SR200 will provide a voltage ramp from 0 to 10 V to scan the SR255 delay on the 100 nS/V timebase scale. The SR200 will provide the X-axis and blanking inputs to the a scope used in the X-Y mode of operation, and the SR255 SAMPLE OUT will provide the Y-axis voltage.

The blow-by compensation can be done on any width scale. Once set up in the sampling scope mode of operation, you need only adjust C213 and C214. These are the variable capacitors found on the teflon PCB at the front of the module. Remember the position of these trimmers before you start: the two adjustments are not orthogonal and you may wish to return to the starting point. To compensate the blow-by signal, simply adjust C213 and C214 for the best pulse shape display of your input signal. If you are unable to adjust the blow-by compensation refer to the troubleshooting section to check for a damaged sampling bridge.

## A/D INPUT OFFSET CALIBRATION

To calibrate the analog to digital converter's input offset, the SR255 will need to be configured as a "sampling scope". Set the gate width to the 100 ps scale, and the delay select to the 1 ns/V range. Use the SR200 Gate Scanner Module to provide a 5 volt ramp at the delay input. Using the SR255 to look at the leading edge of a fast 1 volt pulse (risetime: 1 ns) adjust the 100 ps OFFSET pot so that the rising edge of your signal is crossing zero volts on the oscilloscope. Adjust P401 until there is a smooth and continuous crossing at zero volts.

## CIRCUIT DESCRIPTION

The SR255 Fast Sampler is a single width NIM module which is used to sample voltage waveforms with a sampling gate of 100 pS to 1nS. The module contains all the sub-systems necessary to discriminate a trigger, insert a controllable delay, sample an input voltage, do an A/D conversion, linearize the acquired sample, and output the result in both analog and digital forms.

In the circuit descriptions which follow, please refer to sheets 1 through 4 of the schematic diagrams which are at the back of this manual.

## MODULE POWER SUPPLY

The module is powered by the +/- 12 and +/- 24 VDC supplies of the NIM crate. Each supply line is filtered by a two pole RC filter to reduce noise from other modules in the crate. These filtered lines are then regulated to +/- 5 and +/- 15 VDC for use throughout the module. The approximate current consumption for each of the NIM supplies is given here:

+24VDC	100 mA
+12 VDC	150 mA
-12 VDC	35 mA
-24 VDC	110 mA

The module uses approximately 7.5 Watts of DC power from the NIM crate.

## TRIGGER CIRCUITS

The Trigger Input, J101, is a direct coupled 50 $\Omega$  input. U105, a CA3102 dual differential pair, is used to compare the input with the threshold selected by SW101, the TRIGGER LEVEL switch. Trigger levels of -0.5, +0.1, or +1.0 VDC may be selected.

Q101 and Q102, together with 1/2 of U106, form a fast regenerative latch and a constant current source. Once latched, this circuit will stay latched until both the trigger goes below threshold and the HOLDOFF signal is asserted and released. HOLDOFF is asserted from the time that the unit is triggered until the unit completes the sample acquisition and A/D and D/A conversion, a process which requires about 20  $\mu$ S. While latched, 1/2 of

U106 provides a constant current sink of 11 mA, which is used to discharge a delay one-shot capacitor in order to provide an accurate and very low jitter time delay with respect to the external trigger.

## TIME DELAY CIRCUIT

The PCB mounted Delay Range Select switch is used to select one of four delay ranges: 1, 10, 100 or 1000 nS/V. For example, if the 10 nS/V range is selected, C113, a 200 pF capacitor, is switched into the circuit. Before the trigger occurs, C113 will be precharged to a voltage between 5 and 10 VDC, depending on the input to the External Delay Control. The delay from trigger to gate may be set or scanned by a voltage at this input. Once triggered, the selected capacitor will be linearly discharged by the constant current source 1/2 of U106. When the capacitor has been discharged so that the voltage at the base of Q103 is equal to the voltage at the base of Q104, then the regenerative latch formed by Q103, Q104 and 2/2 of U106 will latch up. There are two outputs from this latch circuit. The TRIGGER signal from the collector of Q104 (active low) is used to start the A/D conversion process, and the positive output from the collector of Q105 is used to trigger the ultra-fast step generator to initiate the sampling of the input waveform.

## STEP GENERATOR

Sheet 2 shows the schematic diagram of the circuit used to sample the signal waveform. All of the components on this page of the schematic are located on the small PCB mounted at the front of the module. This PCB is fabricated on a Teflon substrate to reduce the dispersion which would occur on a conventional glass-epoxy PCB.

The trigger from Q105 on the main PCB is brought to the base of Q201 by a twisted pair. The trigger pulse causes Q201 to go into saturation, thereby injecting a current of about 50 mA into the base of Q202 via the 1:1 transformer, T1-1. Q202, which is normally off, quickly goes into saturation, shorting its emitter and collector together, creating a differential output pulse of +/- 15 Volts with a 1 nS risetime. These pulses are then coupled into the Step Recovery Diode circuit via C202 and C203.

The SRD, D201, is normally forward-biased with about 25 mA via R205, R206, R230, and R231. The 1 nS risetime differential pulses from Q202 are applied so as to reverse-bias the SRD. Even though the SRD is now reverse-biased, it will continue to conduct for a few nanoseconds until all the carriers are cleared from the diode's junction. Once all the carriers are cleared, the SRD will stop conducting very abruptly, injecting a 10V, 50 pS risetime differential pulse on the 40 $\Omega$  transmission line via C204 and C205. The pulse will propagate in both directions on the transmission line: part of the pulse is used to provide a Gate View marker pulse out the front panel connector, J203, and part of the pulse is used to generate a gate to turn on the sampling diodes, D202. The step output from the SRD is turned into a pulse by shorting the transmission line. The pulse width may be set to 100, 200, 500 or 1000 pS by moving the shorting screw to different locations along the transmission line.

### **SAMPLING GATE**

The charge sample that is stored on the sampling capacitors is a.c. coupled to a video pre-amplifier U201, an LM733, via C210 and C211. The gain of the pre-amplifier is set by the four switches, SW201, which are adjacent to the pre-amplifier. The gain is set higher on narrow gate widths in order to compensate for the reduced sampling efficiency of shorter gates.

### **BLOW-BY COMPENSATION**

Whether or not the sampling diodes have been gated ON, the package and junction capacitance of the sampling diodes always provide a path from the signal input line to the pre-amplifier. The signal which couples to the pre-amplifier in this way is called the blow-by signal. In order to eliminate the artifacts caused by this parasitic path, the Blow-by Compensation circuit produces a signal which mimics the blow-by signal, and is applied to the inverting input of the pre-amplifier to cancel the original blow-by signal.

The blow-by circuit consists of C212 to C218 and R218 to R224. C213 and C214 are adjusted to compensate for the unit's particular blow-by characteristics.

### **GATED INTEGRATOR AND SAMPLE AND HOLD CIRCUIT**

The differential output of the pre-amplifier, U201, is brought to the main PCB and a.c. coupled to the gated integrator via C301 and C302. The pre-amplifier's output pulse is only a few hundred nanoseconds long and so it must be sampled and held for the A/D converter. By using an integrator before the sample and hold amplifier, high frequency noise components are reduced: low frequency noise components have already been filtered by a.c. coupling between stages.

The gated integrator is formed from the transistors Q301 to Q307, and their associated bias resistors, R301 to R321. Q301 and Q302 form a differential input amplifier which takes the pre-amplifier's differential outputs and produces a differential current source. Q302's current is mirrored by Q307 and R319 to R321. In this way the pre-amplifier may adjust the current sources to the gated integrator. The current switching gate is formed by Q303 to Q306. Normally, Q303 and Q306 are on, while Q304 and Q305 are off. When the module is triggered, the one-shot, 1/2 of U301, produces a 300 nS gate which is applied to the current switch. Capacitor C304 integrates the difference in the currents from Q301 and Q307 during the 300 nS gate.

Before the current switch directs the current imbalance to the integrating capacitor, the current sources Q301 and Q307 are balanced and the common collector output of Q303 and Q306 is at zero volts. This balance is maintained by 4/4 of U304 which adjusts the bias on the base of Q301. An offset may be injected via R328 and 1/2 of U306. U306 selects one of the four OFFSET pots corresponding to the selected SAMPLE WIDTH.

The voltage on the integrating capacitor is amplified by U302, an LM318 high speed op amp. The op amp's gain is controlled by SW301 which is the front panel SENSITIVITY switch. Since the integrating capacitor is passively reset by R322 with a time constant of 5  $\mu$ S, the output of the LM318 is sampled and held by C306 and 1/4 of U303.

The S/H amplifier has a gain which may be adjusted by one of the four gain pots, P302. There is a different gain pot for each gate width, and the correct pot is selected by 2/2 of U306. These pots are adjusted to produce a full scale output when a full scale input is applied at the Signal Input. Linearization, and a more accurate gain calibration, is done by computer at the factory, and the results of the calibration are stored in the module's PROM.

The output of the sample and hold is passed to a comparator (U305, an LM311) to generate a sign bit. The sign bit is (1) used to select a PROM lookup table for linearization, (2) used to select the polarity of the Last Sample output buffer, and (3) latched into the digital interface latch. The output of the S&H amplifier is also passed to an absolute value circuit to rectify the signal before the A/D conversion.

### TIMING LOGIC

As previously described, a TTL logic level signal, TRIGGER, (active low, source at Q104 on Sheet 1) is generated when the programmable delay times out. The falling edge of this signal is coincident with the sampling of the input signal. TRIGGER is used to trigger 1/2 of U301, a 300 nS one-shot, used to switch the gated integrator, and to trigger the 2/2 of U303, a 1  $\mu$ sec one-shot. This one-shot turns on the switch, 1/4 of U303, in order to sample and hold the output of the gated integrator. The trailing edge of this signal is delayed by R405 and C401 before triggering the A/D converter, U404. After 14  $\mu$ S, the conversion is complete, and the A/D triggers 1/2 of U405 to

generate a 1  $\mu$ S END strobe. The trailing edge of the END strobe will trigger 2/2 of U405, a 10 mS one-shot, which turns on the TRIG LED on the front panel of the instrument.

### A/D AND PROM LINEARIZATION

The absolute value of the sample and hold integrator signal is converted by U404, an 8 bit A/D converter. When the conversion is complete, the 8 bits of data serve as an address to U406, an 8 KByte UVEPROM. The PROM contains the linearization tables for converting the raw 8 bits of data from the converter into 8 bits of linearized and gain corrected data. There are 24 different tables of 256 bytes each burned into the PROM. The tables are addressed by the other address bits presented to U406, i.e. by the width, sensitivity and sign bits.

The PROM's output is passed to U409, an eight bit latch and tri-state buffer IC, to be latched for access via the digital I/O port. The PROM data is also passed to U412, an 8 bit D/A converter. The current output from the D/A converter is converted to a voltage by 2/4 of U411. This voltage is scaled and buffered by 3/4 of U411 before going to the front panel Sample Output. The Sample Output is inverted if the SIGN bit for the latest conversion is positive. The SIGN bit is latched by 1/2 of U415 which drives 3/4 and 4/4 of the analog switch U303 in order to configure the output buffer as an inverting or non-inverting output driver.

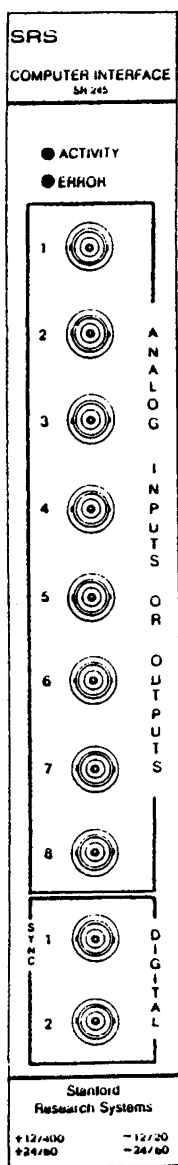
The four most significant bits from the PROM go to 2/2 of U403. If all four bits are high, the output of 2/2 of U403 will be high, and an overrange condition will be indicated. 2/2 of U415, a D-type flip flop, will latch this overrange condition and drive the front panel OVER LED. The voltage reference for the A/D and the D/A conversion is U410, a precision 10.240 VDC reference. This reference is inverted and attenuated to -5.12 VDC for the A/D reference input.



## INTRODUCTION

The SR245 Computer Interface is a versatile module capable of providing a variety of the scanning, counting, and communications functions typically required in the laboratory. It is remotely programmable via both RS232 and GPIB rear panel connectors and can be used with laboratory computers or simply with a terminal. Eight front panel analog ports can be programmed

as inputs or outputs with a range of  $\pm 10.24$  volts. Two front panel digital input/output bits are provided for general use as well as an eight-bit digital input/output port accessible via an internal 20 pin dual in-line connector. The digital ports can be used to interface the SR245 with the SR255 Fast Sampler module. A variety of simple, easily understood commands eliminate the need for extensive software development to integrate the SR245 into existing experiments.



## SPECIFICATIONS

### ANALOG PORTS

#### Inputs

1 M $\Omega$  input impedance, +10.24 VDC range; protected to 40 VDC. 13-bit resolution (2.5mV). Accuracy: 0.05%. Input offset less than 2.5 mV. Maximum A/D rate is 2 KHz.

#### Outputs

Output impedance less than 1 $\Omega$ . Short circuit current limit is 20 mA. 13-bit resolution (2.5mV). Accuracy: 0.05%. Output offset less than 2.5mV.

### DIGITAL PORTS

#### Input Bits

Input impedance greater than 100K $\Omega$ . Minimum pulse width is 200nS. Maximum count rate is 4MHz. Logic one > 3 VDC. Logic zero < 0.7 VDC. Inputs protected to +10 VDC.

#### Output Bits

Can drive loads up to 50 $\Omega$  to TTL logic levels.

#### Internal 20 Pin Connector

8 latched TTL output bits with strobe bit.  
8-bit TTL input port with strobe bit.

### INTERFACES

Both IEEE-488 Std Port and RS232-C(300 to 19.2Kbaud).

### SYSTEM COMPONENTS

Z80-A  $\mu$ P @ 4 MHz. 8K ROM, 8K RAM. VLSI counters, UART, and IEEE-488 adapter.

### GENERAL

#### Power

+24 / 60mA, -24 / 60 mA, +12 / 500 mA, -12 / 20 mA, 8 Watts total. Power from Model SR280 Mainframe or a NIM standard crate.

#### Mechanical

Single width NIM module per TID-20893.  
Dimensions 1.35"x8.714"x11.5".

#### Warranty

One year parts and labor on materials and workmanship.

Figure 22 - SR245 Front Panel



## SETUP & OPERATION

### TRYING OUT THE SR245

Before attempting any detailed programming with the SR245 it is best to get a feel for the type of functions the module provides by using it with a terminal. If one is available, connect a terminal with an RS232 port to the RS232 port on the rear of the SR245. The unit is shipped with its internal configuration switch set for 9.6 kbaud operation. If your terminal requires a different baud rate it will be necessary to open the side panel and readjust the configuration switch according to the values in Figure 23. After setting the correct baud rate and connecting the terminal, turn the unit on. The green ACTIVITY light will flash for a second or two indicating that the SR245 is performing its internal hardware test routines and the sign-on message will appear at the terminal giving the version number of the ROM supplied with the unit. The red ERROR LED may also momentarily flash when the power is turned on; this does not indicate any problem with the unit. If the sign-on message is not displayed, consult Appendix A, Example 1 for more detailed instructions. The last characters displayed will be the prompt 'OK->'. This indicates that the SR245 is ready to accept commands.

Now type the command ?1 followed by a carriage return. The SR245 responds by sending to the terminal the characters 0.000 indicating that the voltage at port 1 is 0 volts. In general, the command ?n causes the SR245 to send back the value at the nth analog port. Now we will use the unit to output a voltage we can read with the ? command. Type the command I4<cr>. This causes the SR245 to configure the first 4 analog ports as inputs, with the remainder becoming analog output ports. For instance, if we wish to set the voltage at port 8 equal to 5.0 volts type S8=5.0<cr> (Set port 8 equal to five volts). We can read the voltage just set by typing ?8<cr> which will return with the value 5.000. Note that the ?<n> can be used to read the voltage at a port regardless of whether it is configured as an input or an output. The ability to use the eight analog ports as either inputs or outputs gives the SR245 tremendous flexibility in laboratory situations. At this point, the user should review Figure 24 containing the complete command list for the SR245, and experiment with a few of the commands.

### COMMUNICATING WITH THE SR245

The SR245 is programmed by sending it strings of ASCII characters via the RS232 or GPIB connectors. The choice of RS232 or GPIB, as well as the details of the actual communications interface used (parity bits, GPIB address, baud rate, etc.) is made by setting the 8 configuration switches inside the unit according to the table in Figure 23. The configuration switch is read only when the unit is turned on or after a GPIB 'device clear' message is received. Thus, changing the value of the switch without clearing the unit or turning it off and on again has no effect. Once the SR245 receives characters over either bus, it looks for the ASCII carriage return character, which signals the end of a line of commands, and processes the commands. Within a given line, there may be many individual commands; these must be delimited by the semicolon (;) character. For instance if we wanted to know the voltages on all of the analog ports we could send the command string:

```
?1;?2;?3;?4;?5;?6;?7;?8<cr>
```

and the unit would respond by returning all the port values. It is not necessary in most cases to wait until the SR245 has finished processing a given line of commands before sending the next: the unit automatically queues the commands and executes each as it is ready. (An exception to this occurs when the unit is operated in synchronous mode.)

The various commands cause the unit to either alter its internal state or send various values back over the bus. Values which are sent by the SR245 are also in the form of strings of ASCII characters followed by a string of terminating characters, usually carriage returns and line feeds. For instance, in responding to the ?1 command the unit might send the string 2.357<cr> to indicate the value 2.357 volts. The choice of terminating characters is determined by whether the SR245 is used in the RS232 or GPIB mode and whether the 'echo' feature is in use. In addition, special terminating sequences may be specified by using the Z command. The default terminating sequences for each of the various modes is shown below. Note that in the GPIB mode the final terminating character is accompanied by the EOI (End or Identify) message.

### Setting The Configuration Switch

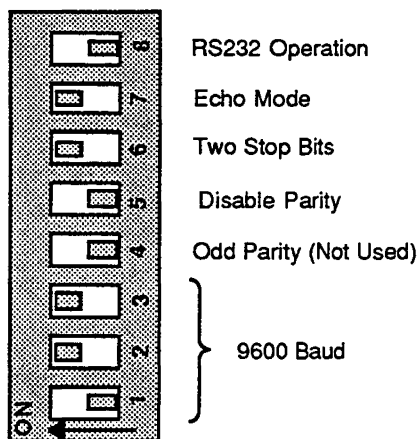
#### RS232 Operation

##### Bit Setting Explanation

8	OFF	Set RS232 operation
7	ON	Echo mode (terminal operation)
	OFF	Disables echo (computer operation)
6	ON	Two stop bits
	OFF	One stop bit
5	ON	Enable parity
		(8 data bits and 1 parity bit)
	OFF	Disables parity
		(8 data bits and no parity bit)
4	ON	Even parity
	OFF	Odd parity
3	} RS232 Baud Rate (see below)	
2		
1		

<u>Baud Rate</u>	<u>Bit 3</u>	<u>Bit 2</u>	<u>Bit 1</u>
300 Baud	OFF	OFF	ON
600 Baud	OFF	ON	OFF
1200 Baud	OFF	ON	ON
2400 Baud	ON	OFF	OFF
9600 Baud	ON	ON	OFF
19.2 Kbaud	ON	ON	ON

#### RS232 Example



#### GPIB Operation

##### Bit Setting Explanation

8	ON	Set GPIB Operation
7	ON	RS232 Echo mode for GPIB
	OFF	GPIB operation without Echo
6	ON	2 stop bits for RS232 echo.
	OFF	1 stop bit for RS232 echo.
5	} GPIB address for module (see below)	
4		
3		
2		
1		

<u>GPIB Address</u>	<u>Bit 5</u>	<u>Bit 4</u>	<u>Bit 3</u>	<u>Bit 2</u>	<u>Bit 1</u>
0	OFF	OFF	OFF	OFF	OFF
1	OFF	OFF	OFF	OFF	ON
2	OFF	OFF	OFF	ON	OFF
.			.		
28	ON	ON	ON	OFF	OFF
29	ON	ON	ON	OFF	ON
30	ON	ON	ON	ON	OFF

#### GPIB Example

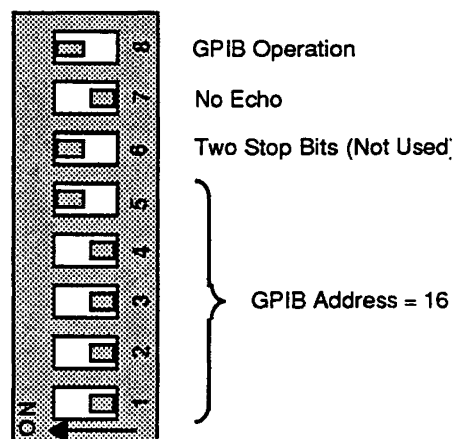


Figure 23 - The Configuration Switch

## DEFAULT TERMINATION CHARACTERS

<u>Interface</u>	<u>Echo</u>	<u>No Echo</u>
RS232	CR, LF	CR
GPIB	CR,LF (EOI)	CR,LF (EOI)

Note that the terminating characters are sent with each value returned by the SR245. Thus, in responding to the command string ?1;?B1;?3<cr> while in the RS232 non-echo mode, the unit would send a string such as 2.000<cr>1<cr>4.875<cr>.

Some commands deal with byte quantities, such as the internal 8-bit digital input/output ports. These values are both sent and received as ASCII coded decimal quantities. For instance, if the user wished to set the value of the digital output port to:

Bit: 7 6 5 4 3 2 1 0  
Setting: 0 0 0 1 0 1 1 0

he would send the command SD=22<cr> because 00010110 binary is equal to 22 decimal. Likewise, if the same binary value were present at the digital input port and the command ?D was sent, the unit would respond by sending the string 22<cr>.

## FRONT PANEL LEDS

The green front panel LED flashes when the SR245 is sending or receiving information over the RS232 or GPIB interfaces. If the green light remains on while the SR245 is not receiving commands, it indicates that the SR245 is trying to send data over the bus but cannot. This will occur,

for instance, if the RS232 'clear to send' line is never asserted, or in the GPIB mode if the unit is never made a talker after requesting data. The red front panel LED flashes whenever an error has occurred, such as an undefined or illegal command string, an A/D overflow, or missed data.

## ECHO AND NO ECHO OPERATION

In order to allow the SR245 to be operated from a terminal, an echo feature has been added which causes the unit to echo back commands received over the RS232 port. This feature is enabled by setting bit 7 of the internal configuration switch ON. In this mode the SR245 will send linefeeds in addition to carriage returns with each value and will also send the prompts 'OK->' and 'ERR->' to indicate that the previous command was either processed or contained an error. When the unit is controlled by a computer, the echo feature should be turned off to prevent the sending of spurious characters. The echo feature can also be used with the GPIB as explained in the section on GPIB operation.

## DTE AND DCE OPERATION

The SR245 contains an internal jumper plug which allows it to emulate either a DTE (terminal) or a DCE (modem) while operating in the RS232 mode. The unit is shipped as a DCE so that it may immediately be connected to a terminal for check out. If it is desired to configure the unit as DTE (connection to many computers will require this) simply pull out the jumper plug from the socket marked 'DCE' on the circuit board and plug it into the socket marked 'DTE'. The plug is located at the rear of the board directly behind the RS232 connector.

**Note:** With newer GPIB cards you may have to add \r to the end of a command to get a proper <cr>.

## PROGRAMMING

In this section, each of the SR245 commands will be discussed in detail. Commands are denoted by boldface characters. The brackets < > indicate that the item named inside the brackets is to be sent with the command. The brackets are never sent as part of an actual command string. Figure 24 provides a brief summary of all the SR245 commands. The symbol <cr> denotes an ASCII carriage return character.

### INPUT / OUTPUT COMMANDS

The SR245 contains three types of input/output ports accessible to the user: the eight analog input/output ports which are referred to simply by their number, 1 through 8; the two front panel bit input/output ports, referred to as B1 and B2; and the 8 bit digital input/output port which is referred to as D. The basic format for interrogating and setting the value of each of these types of ports is the same. To interrogate a port, the command ?<port name> is sent. For instance, to interrogate the value of B2 the user would send ?B2<cr> and the SR245 would respond by sending back either '1' or '0' depending on whether the value at B2 was TTL high or low. To set the value of a port, the command S<port name>=<value><cr> is sent. Thus, to set port 6 to 3.456 volts, we would send the command S6=3.456<cr>. The analog ports may have any value between -10.237 volts and +10.237 volts, the digital bits B1 and B2 are either TTL low or high, and the value of the digital port D may range from 0 to 255.

Certain commands allocate the ports as either inputs or outputs. When the unit is turned on, or after a MR (master reset) command is received, analog ports 1 through 8 and both B1 and B2 are configured as inputs. To configure only the first n analog ports as inputs, with the remainder becoming outputs, the command I<n><cr> is sent. The two front panel digital bits are configured as outputs simply by setting them equal to the desired value, e.g. SB2=1<cr> configures B2 as an output and sets its value to TTL high. To reconfigure the bits as inputs, the command SB<n>=I<cr> is used. Note that certain commands automatically reconfigure the input/output status of B1 and B2 regardless of their previous value.

For instance if the PB1 command is sent (Pulse Bit 1), B1 is reconfigured as an output even if SB1=I had been previously sent.

### SYNCHRONOUS AND ASYNCHRONOUS MODES

The SR245 can operate in one of two modes, called the synchronous and asynchronous modes, which dictate when the unit will send back the requested values in response to a ? command. In the asynchronous mode, the power on default mode, the unit returns each value immediately after it is requested. Setting synchronous mode operation allows the SR245 to respond to certain commands only in response to an external trigger signal. When the synchronous mode is set using the MS command, front panel bit 1 (B1) is automatically configured as an input and reserved for use as a trigger. In this mode, when a ? command is sent, the SR245 will wait until a trigger is received at B1, at which time it will sample the requested values and send them back over the bus. A 'trigger' consists of the falling edge of a standard TTL pulse. Note that all the commands on a given line are processed after the first trigger following the carriage return which delimits that line of commands. In other words, if the string ?1;?2;?3<cr> is sent in the synchronous mode the unit will wait for a trigger and then send the values of ports one, two, and three.

While the SR245 is waiting for a trigger, commands may be sent to it normally. If operating in the RS232 echo mode, the next 'OK->' prompt will not be displayed until a trigger is received and the previously requested values are sent. Note that if another string containing ? commands is received while the unit is still waiting for a trigger to send back the result from a previous ? command, the first command is flushed and the next trigger will cause the unit to respond only to the latest ? command.

### TRIGGER COMMANDS

Certain commands modify the properties of the trigger input. For instance, if the user wishes every nth pulse at B1 to trigger the unit, he can give the command T<n><cr> while in the synchronous mode. The value of n can range from 1 to 32767.

A trigger can be induced without externally pulsing B1 by sending the PB1 command (Note that this will leave B1 configured as an output.) The trigger can be masked by sending the command DT (disable trigger). To re-enable the trigger after this command has been sent, the command ET (enable trigger) is used.

### PULSING COMMANDS

Both B1 and B2 can be used as general purpose TTL pulse sources using the P command. Sending PB1<cr> or PB2<cr> configures the appropriate bit as an output and outputs a 10μsec positive TTL pulse. The SR245 may be programmed to act as a 'divide by n' counter by sending the command P/<n><cr> when the unit is in the synchronous mode. This command causes the SR245 to output a 10μsec pulse on B2 every nth trigger. Note that the effects of the T command and the P/<n> commands are cumulative. Thus, if the user had set T10 and then gave the command P/5, a pulse would be output at B2 for every 50th input pulse at B1.

### COUNTING COMMANDS

The SR245 may be used as a general purpose counter using the C and ?C commands. Sending the C command configures B2 as an input and initializes the counter. Sending ?C<cr> causes the SR245 to return the number of pulses counted at B2 and clears the counter in preparation for a new count. Note that the C command does not have to be sent before each ?C, but if B2 is ever reconfigured as an output the C command must be sent to reinitialize the counter before using ?C again. The maximum count rate is 4MHz. The maximum count is 65,535. The counter 'wraps around' to 0 and continues counting after the maximum count is reached.

### SCAN COMMANDS

One of the most useful features of the SR245 is its ability to independently read the input ports and store a series of data points. The scan command format is:

SC<port 1>,<port 2>,...<port n>:<num of triggers>

A maximum of 8 ports may be specified. This command causes the unit to sample and store the values of specified input ports each time a trigger is received. This process is repeated for the number of triggers specified in the command. For instance if we wanted to scan the values of ports 1 and 3 as well as the digital port for 100 triggers we would give the command:

SC1,3,D:100

The eight analog ports and the 8-bit digital port may be scanned in this manner. The two bits B1 and B2 may not be included in the scan command. When the required number of triggers has been received, the SR245 stops scanning and sets the 'scan finished' bit (bit 4) in the status byte. To stop the scan prematurely, the command ES (end scan) may be used. The number of triggers received since the scan started is returned by the ?N command which may be sent any time during the scan. Other commands may be sent while a scan is in progress, but, since processing these commands takes time, this practice is not recommended, especially at scan rates close to the maximum. The maximum scan rates, as well as the maximum number of points in a scan is shown in the table below.

Maximum Scan Parameters (SC Command)

<u># of ports</u>	<u>Max trig rate</u>	<u>Max # of triggers</u>
1	2.1 KHz	3711
2	1.3 KHz	1855
3	910 Hz	1237
4	740 Hz	927
5	600 Hz	742
6	510 Hz	618
7	440 Hz	530
8	390 Hz	463

Once a scan has been completed the user may read the stored values with the N (next point) command. Each time the N command is sent, the SR245 returns the next value in the scan. The value of the ports are sent in the same order as they were specified in the scan command. Thus if SC4,6,1:50 were sent, the scan points would be sent in the following order:

## Command List

### Input/Output Commands

**I<n>** n=0-8 Designates the first n analog ports as inputs, the remainder become outputs. Default is 18.

**?<n>** n=1-8 [?3;?5] Returns the value of the designated analog port.

**?B<n>** n=1,2 [?B1] Returns the value (0 or 1) of the designated digital bit port.

**?D** Returns the value of the internal 8 bit digital input port.

**?S** Returns the value of the status byte, and clears the status byte.

**C** Configures B2 as an input and resets the B2 counter.

**?C** Returns the number of pulses occurring at B2 since the previous ?C.

**S<n>=<x>** n=1-8; x=-10.237 to +10.237 [S8=6 or S2=-41.5E-2] Sets the analog port n (which must be designated as an output) to the value x Volts. x may also be expressed in exponential format with a two digit exponent preceded by an E.

**SB<n>=<m>** n=1,2; m=0,1 [SB1=1] Designates digital bit n as output and sets its value to TTL low if m=0 or high if m=1.

**SB<n>=I** n=1,2 [SB2=I] Designates the selected bit as an input.

**SD<n>** n=0-255 [SD=128] Sets the 8-bit digital output port to the value n.

**SM<n>** n=0-255 [SM=16] Sets the GPIB SRQ mask to the value n (See GPIB discussion).

### Trigger Commands

**MS** Sets the synchronous mode. Responses to ? commands are returned immediately after the next trigger.

**MA** Sets the asynchronous mode (default). Responses to ? commands are returned right after command is received.

**T<n>** n=1 to 32,767 [T3] Designates every nth pulse at B1 as a trigger.

**DT** Masks the trigger input so that no triggers are recognized.

**ET** Unmasks the trigger input.

**PB<n>** n=1,2 [PB2] Outputs a 10μsec TTL pulse at bit port n.

**P/<n>** n=1-255 [P/3] Outputs a 10μsec TTL pulse at B2 each nth trigger.

### Scan Commands

**SC<i>,<k>:<n>** i..k=1-8,D [SC1;3,D:500] Scans the list i..k of analog ports or digital port for n triggers. Total # of samples may not exceed 3711.

**ES** End the current scan immediately and reset the point sending counter.

**N** Send the next point of stored scan.

**?N** Returns # of points scanned.

**A<n>,<i>** n=1-255; i=1-255 [A16,2] Adds n x 2.5mV to the value of analog port 8 (must be a positive output) on every ith trigger.

**SS<i>,<k>:<n>** i..k=1-8,D [SS1:10] Scans the list i..k of analog ports or digital port for n triggers. Data is sent in a 2 byte binary format while the scan is in progress.

**X** Sends the data of a stored scan in 2 byte binary format.

### Miscellaneous Commands

**MR** Master Reset. Returns the SR245 command settings to their default values.

**W<n>** n=0-255 Introduces a delay of approximately n x 400μsec before sending each character over the RS232. Default is W255. Allows slow peripherals to keep up.

**Z<i>,<k>** [Z13,13] Changes the end-of-record characters sent by the SR245 to those specified by the ASCII codes, i...k.

Figure 24 - The SR245 Command List

```

port 4 at 1st trigger
port 6 at 1st trigger
port 1 at 1st trigger
port 4 at 2nd trigger
.
.
.
port 1 at 50th trigger

```

The N command may not be sent while a scan is in progress. If N is sent after the entire scan has already been read, a 'command parameter out of range' error is generated setting bit 2 in the status byte and blinking the red LED, and no value is returned. The 'next point' pointer can be made to point to the beginning of the scan at any time by using the ES command. The pointer is automatically reset to the beginning of the scan following completion of a scan.

The SR245 has a limited capacity to ramp one of its analog output ports during a scan. The command A<n>,<m> causes the unit to add  $n \times 2.5$  mV to the value of port 8 (port 8 must be configured as output) at each mth trigger. Using the A command reduces the maximum trigger rate by about 20%. The starting value of port 8 should be set using the S8= command and port 8 must have been set as an output with the I command. Both m and n may range from 1 to 255. When the output reaches its maximum value of +10.237 volts it 'wraps around' and begins ramping at 0. The A command may not be sent when the value of port 8 is negative. This ramping output may be used to drive, for instance, the 'external delay' input of the SR250 boxcar integrator.

#### RECEIVING DATA WHILE SCANNING: THE SS COMMAND

It may sometimes be desirable to receive scan data from the SR245 while a scan is in progress. This can be accomplished with the SS command;

```
SS<port 1>,<port 2>,...,<port n>:<num of triggers>
```

When this command is received the SR245 begins scanning the designated ports as in a normal scan. Instead of storing the data so that it may be read back later the SR245 sends each scan point over the bus as it is read. The values of the ports are not sent as ASCII characters in this case. Analog

ports are sent as 2 binary bytes which represent a sign bit and 12 data bits. The first byte sent contains the sign bit (1=negative, 0=positive) in the bit 4 position and the high 4 data bits in bits 3 through 0. The second byte sent contains data bits 7 through 0. The analog voltage may be reconstructed by multiplying the signed integer by 0.0025 volts. The digital port value is sent as a single byte preceded by a dummy identifier byte with a value of 0FFH (11111111 binary). At the conclusion of the scan, two dummy bytes with the value 0FFH are sent when in the RS232 mode. In the GPIB mode, the last byte is sent with the End-of Identify message (EOI).

When the SS command is given, the user should be prepared to read the data which is being sent by the SR245 as fast as it is being accumulated. Untransmitted data bytes are temporarily buffered up to a maximum number of 7420. If the number of unread data bytes exceeds 7420, the scan is stopped and a 'missed data' error is generated. Note that the normal restrictions on the number of points scanned do not hold for the SS type of scan. The only restriction in this case is that the total number of bytes sent during the scan must be less than 65535. The number of bytes may be calculated simply by multiplying the number of points in the scan by the number of ports scanned at each point times 2 bytes per port. Thus, SS1:25000 is a legitimate command since it only requires sending 50,000 bytes.

Because the SS command may require that the user be able to acquire unformatted binary data at high data rates, it will not be usable with all languages or with all computers. Special I/O drivers may be necessary to take advantage of this feature. Examples of how this is done are provided in Appendix A. If the additional power provided by the SS command is not required, the user may acquire data in a much simpler manner using the SC and N commands.

#### FAST TRANSFER OF SCAN DATA: THE X COMMAND

When many data points are acquired during a scan, the amount of time necessary to transfer the scan data to the user's computer using the N command may become significant. To allow for faster transfer of scan data, the X command can be used to cause the SR245 to send the entire scan over the

RS232 or GPIB lines in binary format. When the X command is received, the SR245 first waits for approximately  $37 \times W$  mS to allow the user's computer time to prepare for the incoming data. W here is the 'wait' value that is set using the W command. After waiting for this time period, the SR245 begins sending the stored scan data, byte by byte, in the same format used in the SS command; i.e. the first byte contains the sign bit and the 4 high data bits, and the second byte contains the low 8 data bits. The digital port value is sent as a single byte preceded by an 'identifier byte' equal to 0FFH (11111111 binary).

If, at any point during the scan dump, the SR245 has to wait for more than 9 mS for the 'clear to send' signal in the RS232 mode or for 'ready for data' (RFD) from all listeners in the GPIB mode, the scan dump is abandoned and the remainder of the data is not sent. Thus, using the X command requires the user's computer to become a dedicated listener while the data is being transferred. When all the data has been sent, the SR245 finishes the dump by sending two terminating 'FF (hex)' bytes in RS232 or a single 'FF (hex) byte with the EOI message in GPIB. Note that these terminating characters are always sent when the X command is used and are not affected by the choice of terminating characters made with the Z command.

## INTERFACING WITH THE FAST SAMPLER

Commands are provided which allow the SR245 to scan the SR255 Fast Sampler module. Consult the SR255 section of this manual for information.

## MASTER RESET

The MR (master reset) command resets the unit to its default state. All ports are configured as inputs. Any data which is waiting to be sent is lost. Therefore it is bad practice to place a MR command on the same line following a ? command as the unit will send an indeterminate number of characters in response to the ? command before processing the MR command and flush the remainder of the response.

## WAIT COMMAND

The SR245 normally waits until the 'Clear to Send' line on the RS232 bus is asserted before sending

characters over the bus. However, as some peripherals may not bother to set and reset the CTS line, it is possible for the SR245 to send data out at a rate too fast for some computers and terminals to handle. The SR245 may be 'slowed down' using the W command. Sending  $W\langle n \rangle \langle cr \rangle$  ( $0 < n < 255$ ) causes the unit to wait about  $n \times 400$  usec before sending each character over the RS232 bus. Note that the default setting for the wait parameter is W255. Thus, to operate at the fastest data rate over the RS232, it is necessary to set the wait parameter to some lower value each time the unit is powered on.

## SETTING THE TERMINATION SEQUENCE: THE Z COMMAND

Although the default terminating characters described above will suffice for interfacing the SR245 with a wide variety of hardware and software, it will occasionally be necessary to send special terminating sequences to fit the requirements of some computers. This can be done with the Z command. The format for the command is:

$Z\langle n1 \rangle, \langle n2 \rangle, \langle n3 \rangle, \langle n4 \rangle$

where  $n1$ ,  $n2$ ,  $n3$ , and  $n4$  are decimal values between 0 and 255 corresponding to the ASCII codes of the desired termination characters. For instance, if we wanted to send each value followed by the "" character (ASCII 42), two carriage returns, (ASCII 13) and a line feed (ASCII 10) we would send:

Z42,13,13,10

If a ?1 command was received after this command had been sent and the voltage at port 1 was 2 volts, the string of characters sent back by the SR245 would be 2.000\* $\langle cr \rangle \langle cr \rangle \langle lf \rangle$ . Up to 4 terminating characters may be sent with the command. Note that the Z command only affects the characters sent by the SR245. Command lines received by the SR245 must always be terminated by the carriage return character regardless of the Z command.

For GPIB, the 'E' character (ASCII 69) has special significance. Requesting 'E' as part of a terminating sequence causes the character preceding the 'E' to be sent with the end or



identify (EOI) message (an ASCII 'E' will not be sent.) The 'E' character should always be the last character in the terminating sequence when using the GPIB; when not using the GPIB-RS232 echo mode, the 'E' character must be the last character in the terminating string.

## STATUS BYTE

The SR245 contains an 8-bit status register which the user may read to obtain information on the unit's status. The status byte may be read in two ways: by sending the ?S command, which returns the value of the byte in ASCII coded decimal, or when using the GPIB, by performing a serial poll. The status byte returned by the unit reflects all of the status conditions which have occurred since the last time the byte was read. After the status byte has been read, it is cleared by the SR245. Thus, in

situations where it is critical to monitor a status condition, the status byte should be read initially to clear all previous conditions. The status bits are described in detail in Figure 25.

## ERRORS

Whenever a 'parameter out of range' or an 'unrecognized command' error occurs, the appropriate status bits are set and the red LED flashes. In addition, the command queue is reset so that any commands which were pending at the time the error occurred are not executed. Note that an 'A/D overflow' or a 'missed data' error do not reset the command queue or interrupt the processing of commands. In the former case, the overflow value is stored as 10.237 volts and in the latter, the scan is continued even though triggers are being missed. It is the user's responsibility to check for these errors.

### The Status Byte

Bit	Value	Explanation
b7	128	<b>Busy.</b> When this bit is set it indicates the SR245 has one or more unprocessed commands pending on its command queue. For RS232, this bit is always high as the ?S command will itself be an unprocessed command.
b6	64	<b>SRQ.</b> This bit indicates that the SR245 has requested service from the GPIB controller. This occurs when one of the status bits which the user has 'unmasked' with the SM= command is set. The SRQ bit is reset when the controller performs a serial poll and reads the status condition which generated the SRQ.
b5	32	<b>Trigger received.</b> Indicates that the SR245 has been triggered.
b4	16	<b>Scan finished.</b> This bit is set at the completion of a scan.
b3	8	<b>Missed data.</b> This bit is set when the trigger rate in the synchronous mode exceeds the allowed maximum (see Note 1.)
b2	4	<b>Command parameter out of range.</b> This bit is set if a parameter associated with a command is not in the allowed range. For instance, S8=45 or SC1:10000 will both generate out of range errors (see Note 2.)
b1	2	<b>A/D overflow.</b> This bit is set whenever the unit reads a value at one of the input ports which exceeds +10.237 volts.
b0	1	<b>Unrecognized command.</b> Indicates that the unit has received an illegal command string (see Note 3.)

#### Note 1: Missed Data

- 1) External trigger rate is too fast.
- 2) Command queue overflow.
- 3) Transmission buffer overflow.
- 4) Available buffer space exceeded in SS command.

#### Note 2: Parameter Out of Range

- 1) Scan command designates more than 8 ports to be scanned.
- 2) Number of scan points specified in the SC command is 0 or greater than the maximum allowed.
- 3) SS command requires sending greater than 64k bytes.
- 4) The A command is sent when port 8 is <0.
- 5) Either parameter in A command is >255 or second parameter =0.
- 6) Any parameter in Z command is >255.
- 7) ?C command is sent when B2 is an output.

- 8) S command specifies an analog port configured as an input.
- 9) Parameter in I command is >8 or <0.
- 10) Analog value in S command is >10.2375 volts or <-10.2375.
- 11) Parameter in SD command is >255 or <0.
- 12) Parameter in SM command is >255 or <0.
- 13) Try to set nonexistent port or bit with S command.
- 14) Parameter in SB command is <0 or >1.
- 15) Time out on X command.
- 16) N command received during a scan.
- 17) X command received during a scan.

#### Note 3: Unrecognized Command

- 1) Illegal character in a command string.
- 2) <cr> or ';' not detected at end of command.
- 3) Non numeric value detected in a numeric string.
- 4) '=' character missing in S command.

Figure 25 - The Status Byte

## COMMUNICATIONS

### INTRODUCTION TO RS232

The RS232 is a standard for bit serial asynchronous data communication. The standard defines the format for data transmission, electrical specifications for signal levels, and mechanical dimensions of connectors.

Despite the existence of a definition of a standard, there are so many permutations of control lines, data formats, and transmission speeds, that getting two RS232 devices to communicate usually requires some work. In this section, we will provide some basic information to aid you in connecting your RS232 device to the SR245 Computer Interface.

#### Case 1 - The Simplest Configuration

In this case, one wire is used to send data from device A to device B and another wire is used to send data from device B to device A (Figure 26.) Notice that pin 2 is an output on device A and an input on device B. The RS232 defines two types of devices; DTE (Data Terminal Equipment) and DCE (Data Communications Equipment). An RS232 port on a computer may be either a DTE or DCE but nearly every terminal with an RS232 port

is a DTE. The SR245 may be configured as either a DTE or a DCE by placing the 16 pin header on the circuit board in either the DTE or DCE socket.

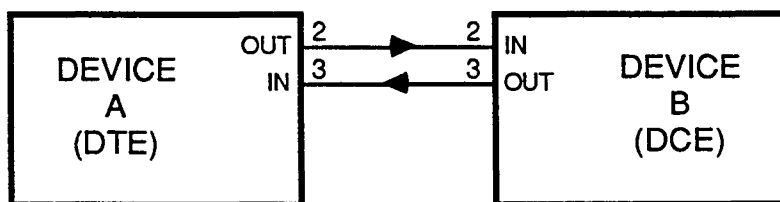
As an example, consider connecting an RS232 ASCII computer terminal to the SR245 (specific details are contained in Example 1 of Appendix A.) The terminal will be DTE and so the SR245 header must be in the DCE socket. To operate correctly, the SR245 and the terminal must have the same settings for baud rate, parity, and number of stop bits. Even set correctly, it may not work as there are other lines in the RS232 Standard which are used to indicate that a device is ready to accept data. If the terminal responds to this line, it will believe that the SR245 is not ready to accept data and will therefore not send any data.

#### Case 2 - RS232 With Control Lines

The data lines are the same as in Case 1. In addition, two control lines are used:

CTS (Pin 5)	'Clear To Send' is a signal asserted by the DCE to tell the DTE that the DCE is ready to receive data.
DTR (Pin 20)	'Data Terminal Ready' is a signal asserted by the DTE to tell the DCE that the DTE is ready to receive data.

Case 1  
The Simplest Configuration



Case 2  
RS232 With Control Lines

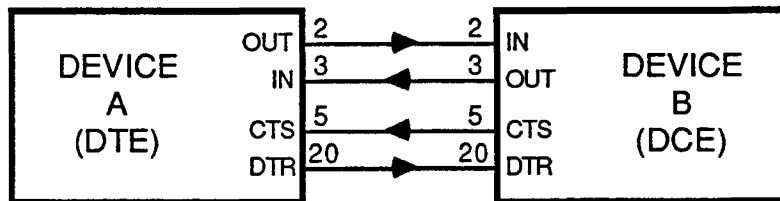


Figure 26 - RS232 Communication

The SR245 responds to the control lines as follows:

- 1) If the lines are not connected, the SR245 assumes that you are ready to receive data.
- 2) Data will not be transmitted from the SR245 if the DTR line (pin 20) is low (SR245 configured as a DCE) or the CTS line (pin 5) is low (SR245 configured as a DTE). This is useful in the case when your program has asked for data but is not yet ready to receive it. If data transmission is not suspended, then data can be overwritten in the UART (it is not being retrieved by the program) and therefore lost. When this happens, the 'over-run' flag will be set in your computer's UART and it may be recognized by the operating system generating an error message such as "I/O Device Error". See the "W" command in the Command List (Figure 24.)

#### Baud Rates

The RS232 baud rate of the SR245 is switch selectable from 300 to 19.2K baud (see configuration switch setting Figure 23.) 19.2K baud means that data is transmitted at 19,200 bits/second. With one start bit, 2 stop bits, 8 data bits, and no parity bits, each ASCII character

requires 573  $\mu$ sec to be transmitted (11bit/19.2K baud.) A typical data string 5.127 <cr> has 6 characters, requiring 3.4 msec to be sent, resulting in a maximum data transfer rate of 290 samples/sec. If the SS or X command is used, then the transfer rate is increased to about 1000 samples/sec.

#### Stop Bits

Generally, selection of 2 stop bits will result in fewer data transmission errors.

#### Parity

The Parity bit provides a check against data loss. They are not commonly used in a local data transmission environment. If the parity option is selected, the SR245 will transmit 8 data bits and a parity bit, however, no parity check of incoming data is done.

#### Voltage Levels

The RS232 uses bipolar voltage levels (Figure 27.) The control lines use positive logic. For example, the DCE tells the DTE that it is clear to send (CTS) by placing >+3 VDC on pin 5 of the interface. Similarly, the DTE can tell the DCE that it is not

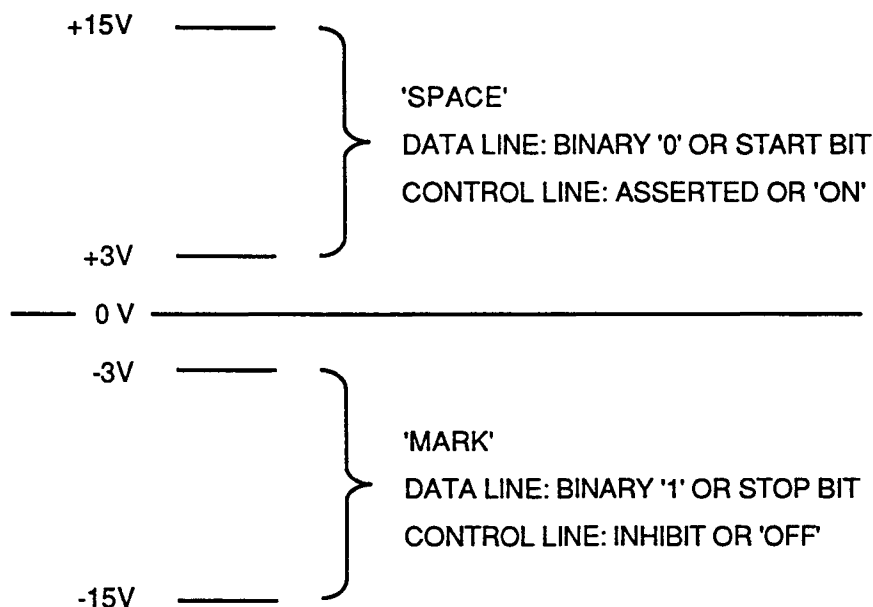


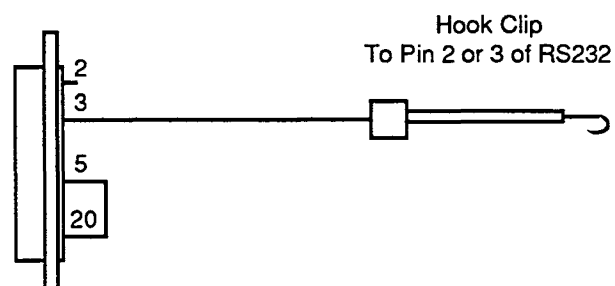
Figure 27 - RS232 Voltage Levels

ready by placing -3 VDC on pin 20 (DTR) of the interface. The data lines, pins 2 and 3, use negative logic. A 'zero' bit is represented by a positive voltage and a 'one' bit is represented by a negative voltage. A start bit is a positive voltage and a stop bit is a negative voltage. Data is transmitted with the least significant bit first. The letter 'A', which has the ASCII code 41H (0100 0001), would appear as in Figure 28. If a parity option was selected, the parity bit would be sent after the 8th data bit, but before the first stop bit.

### 'Eavesdropping'

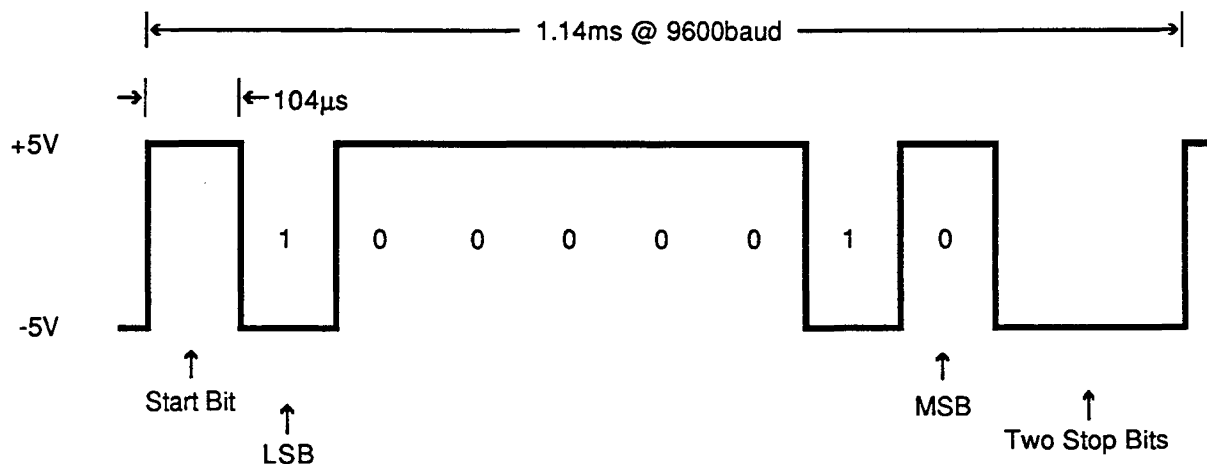
When you are trying to get the RS232 to work with your computer, it is helpful to be able to 'eavesdrop' on the RS232 data lines going between the SR245 and the computer. This can be done with an ASCII RS232 computer terminal and the connector shown in Figure 29. To test the connector, place the hook clip on pin 2 of the same connector (shorting pin 2 to pin 3). Now, when you type at the terminal keyboard, data transmitted from pin 2 is received at pin 3 and displayed on the terminal screen. To use as a debugging tool, attach the hook clip to either pin 2

D-Subminiature  
25 Pin  
RS232 Connector



**Figure 29 - Eavesdropper**

or pin 3 of the RS232 data lines to show either data sent from the DTE or DCE (The hook clip may be placed on one of the top 2 lines in the DTE/DCE Header in the SR245). The baud rate, parity, and stop bits of the terminal must match those of the SR245 and the computer. If your terminal has a mode which will display control characters (such as carriage returns and line feeds) it is helpful to operate in that mode.



**Figure 28 - The Letter 'A'**

## INTRODUCTION TO GPIB

The IEEE-488 Standard specifies the voltage levels, handshake requirements, timing and hardware details, including pinout and connector dimensions, for a 16 line byte serial bit parallel bus configuration. One major characteristic of this interface is that many instruments may communicate over the same cable and through the same port. Also, because the bits are passed in parallel, it offers speed advantages over the RS232 (about 20  $\mu$ S per byte).

The controller (generally your computer) coordinates data transfer on the bus by designating all participating instruments (including itself) as either a talker or a listener. Listeners can receive data placed on the bus by the Talker. Devices can have the capacity to operate in either mode. The address of each device is set by switches in the device and must be between 0 and 30.

### BUS DESCRIPTION

**BYTE TRANSFER CONTROL GROUP.** This consists of 3 negative logic lines that implement the GPIB handshaking. The NRFD (Not Ready For Data) line is held low by any designated listener who is not ready to accept data. When every listener is ready, the line goes high and the talker may release data to the bus. After data is on the bus, the talker pulls the DAV (Data Valid) line down. At this point, each listener retrieves the data. Before and during the retrieval of the data, the listener holds the NDAC (No Data Accepted) line down. When every listener has received the data, the NDAC line goes high, allowing the talker to release the DAV line high. Finally, the listener pulls down the NDAC line until another transfer is initiated.

**DATA BUS:** There are eight data lines which use negative logic and pass the bits of each byte in parallel.

**GENERAL INTERFACE LINES:** These five lines operate independently of the handshake lines and use negative logic.

- 1) The EOI (End or Identify) line is used by the talker to designate the end of message.
- 2) The SRQ (Service Request) line is used by any

device to ask for service. The controller can serial poll each device (each device returns an 8 bit status byte) to determine who needs attention. It can also do a parallel poll using the EOI and ATN lines where each device is assigned a single data line.

- 3) The ATN (Attention) line makes both talkers and listeners accept information and passes control of the DAV line to the controller. This line is used by the controller to identify talkers and listeners through their addresses.

- 4) The REN (Remote Enable) line changes the status of an instrument from local to remote.

- 5) The IFC (Interface Clear) line clears the bus of all data and activity.

A complete description of the General Purpose Interface Bus is beyond the scope of this manual. The user should consult the manual for the particular GPIB controller he is using for specific information on how to send and receive characters over the bus, how to perform serial polls, etc. Instead, we will look at those features and commands of the SR245 which relate specifically to the GPIB.

### GPIB CAPABILITIES OF THE SR245

The GPIB capabilities of the SR245 consistent with IEEE-488 standard (1978) are shown in Figure 30. Note that the unit has no parallel poll capability. The responses of the SR245 to some of the IEEE-488 standard commands are shown in Figure 31.

<u>Code</u>	<u>Function</u>
SH1	Source handshake capability
AH1	Acceptor handshake capability
T5	Basic Talker, Serial Poll, Unaddressed to talk if addressed to listen
L4	Basic Listener, Unaddressed to listen if addressed to talk
SR1	Service request capability
RL0	No remote-local capability
PP0	No parallel poll capability
DC1	Device Clear capability
DT1	Device Trigger capability

Figure 30 - SR245 GPIB Capabilities

<u>Mnemonic</u>	<u>Command</u>	<u>SR245 response</u>
DCL	Device Clear	Equivalent to Power On
SDC	Selected Device Clear	Equivalent to Power On
GET	Group Execute Trigger	None in Asynchronous Mode In Synchronous, same as a trigger at B1
SPE	Serial Poll Enable	Places status byte on bus and clears status byte

**Figure 31 - SR245 Response To Standard GPIB Commands**

### SETTING THE ADDRESS

The GPIB address of the SR245 is set using bits 5 through 1 of the configuration switch. Bit 5 is the most significant bit, and setting a given switch 'ON' is equivalent to making it a binary 1. The unit is shipped configured for RS232 operation so the configuration switch must be set the first time the unit is used with the GPIB.

### SERIAL POLLS AND SERVICE REQUESTS

The status byte sent by the unit when it is serial polled is the same status byte which is read using the ?S command. Of course, when the SR245 is serial polled, it does not encode the status byte as a decimal number. The user can program the SR245 to generate a service request (SRQ) to the controller every time a given status condition occurs. This is done using the SM=<n> command. The mask byte M which is set with this command is periodically logically anded with the status byte. If the result is nonzero, the SR245 generates a service request and leaves the status byte unchanged until the controller performs a serial poll to determine the cause of the service request. When the unit has been serial polled, it loads a new status byte which reflects all of the status conditions which have occurred since the service request was generated. For instance, suppose we wanted to generate a service request each time a scan was finished or the SR245 missed data. We would send the command SM=24 since 24 decimal is 00011000 binary which corresponds to the 'missed data' and 'scan finished' bits in the

status byte. If, during the course of a scan, the unit was triggered too fast and missed data, a service request would be generated. If the unit serial polled the SR245 before the scan finished, then the first serial poll would reveal only the 'missed data' condition, after which the SR245 would load the new status byte reflecting the 'scan finished' condition and generate a new service request. It is particularly useful to use the SM command to unmask the 'Scan Finished' bit. This eliminates the need to use the ?N command to detect the completion of a scan, increases the maximum data rate and leaves your computer free for other tasks during the scan.

### GPIB RS232 ECHO MODE

It is sometimes useful when debugging a GPIB system to have some way of monitoring exactly what is going back and forth over the bus. The SR245 has the capability to echo all characters sent and received over the GPIB to its RS232 port. This mode of operation is set by turning bits 8 and 7 of the configuration switch ON. This will automatically configure the RS232 port for 9600 baud, no parity operation. The number of stop bits is still user selectable with configuration switch bit 6. Of course, since the RS232 port operates at much lower speeds than the GPIB is capable of, the GPIB cannot be operated at high data rates in this mode. It is useful, however, for determining if what is actually being sent to the SR245 corresponds to what is supposed to be sent to the SR245.

## TROUBLESHOOTING

1) SR245 Problem. If, when the power is initially applied, both the RED and GREEN LED's come on and stay on, then the SR245 memory is defective and the unit should be returned for service.

2) RS232 Eavesdropping. This is described in the communications section at the end of the RS232 description..

3) Emulating the SR245 with a Terminal. When trying to debug RS232 interfaces, it can be useful to substitute an RS232 terminal for the SR245. This will allow you to both see what is being sent to the SR245 by the program, and supply responses to the computer via the terminal's keyboard (responses normally sent by the SR245).

For a computer with an RS232 port configured as a DCE, simply substitute the terminal (a DTE device) for the SR245. For a computer with an RS232 port configured as a DTE (i.e. the ASYNC port on the IBM PC) a "null modem" cable is necessary to connect the computer terminal to the DTE port. This cable is made by swapping lines on the RS232 to allow two DTE devices to be connected together (Figure 32).

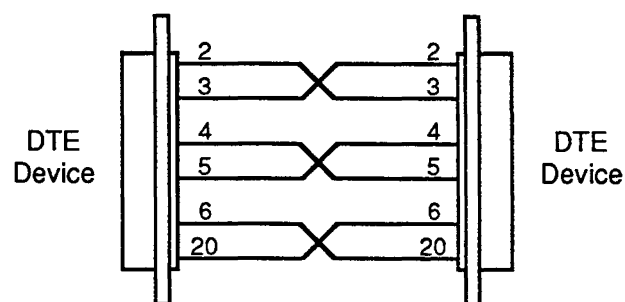


Figure 32 - Null Modem Cable

4) GPIO Eavesdropper. When debugging an IEEE-488 (GPIO) interface, an ASCII terminal (9600 baud only) may be used to view the GPIO transaction on the RS232 connector of the SR245 when the Echo switch (switch 6) is on. A GPIO extender is helpful in allowing the simultaneous connection of GPIO and RS232. When using this technique, the W0 command should be sent to the SR245 so that the GPIO will not be unnecessarily slowed by the terminal. The SR245 must be configured as a DCE so that it may talk to the terminal, a DTE device.

5) Program 'hanging' due to hardware problems. When your computer and the SR245 are talking, it is very easy for the system to "hang." This may occur because the computer is waiting for a response from the SR245 which does not come because:

- The RS232 or GPIO cable was not attached or has come loose.
- The configuration switches are not set properly (Baud rate, parity, stop bits, GPIO address conflict). Also, the switches can be set correctly, but the power must be turned off and then on again before the SR245 will read them.
- The 16 pin Header to select DCE or DTE is not in the correct socket.
- Your computer requires a control line of the RS232 to be asserted, but you are only using two wires for your cable.

6) Program 'hanging' due to software problems:

- The SR245 is in the "Mode Synchronous" and is waiting for a trigger input before sending data.
- The command from the program asking for data was invalid, or a transmission error occurred (ex. we have observed Microsoft's interpreted BASIC on the IBM PC occasionally send a curly bracket (ASCII 0FDH) instead of a carriage return (ASCII 0DH). When this happens, the SR245 sends no response as it is waiting for the carriage return to end the command.
- The initial command was invalid because of a "garbage character" which was sent by the computer when it was turned on. It is good practice to send several carriage returns and a ?S when the program starts to clear out bad characters and any resulting errors.
- The SR245 is not sending the correct 'end-of-record' marker for your computer. For example, it appears that Microsoft's Rev 3.2 FORTRAN on the IBM PC under DOS 2.0 requires two carriage returns for an end-of-record marker. The Z command can be used to set the SR245 end-of-record marker to 2 carriage returns. [The end-of-record marker is that sequence which indicates that the response is complete. From the keyboard, a single carriage return is the end-of-record marker.]
- Answers are coming back from the SR245 too fast, overwriting the end-of-record markers, and causing the computer to hang waiting for a complete response. In this case, the W command can be used to slow down the response time of the SR245 preventing overwriting.



f) The command, though formatted correctly, was invalid due to incorrect initializing of the SR245 relative to the command: for example, S8=2 is an invalid command if port 8 has not been designated an output port. Note that a previous program or user can leave the SR245 initialized in a variety of configurations incompatible with your program. Including a MR in your program is good protection against this situation.

g) The command, though formatted correctly, was invalid due to parameter limitations such as: SC1:4000 overruns the memory; "S8=",A where the program has set A = 11 and is out-of-range; and A6,1 when port 8 was left at -1 volt.

h) A command was sent too early, as in asking for N prior to completing the scan.

i) The command was invalid due to syntax errors. These errors can occur simply, as in using ",", instead of ";" to separate commands, or more obscurely, such as "S",A,"=5" where A is a variable which produces an error because it is sent with leading blanks. Leading blanks are allowed for variable settings, but not in command codes.

7) Incorrect Data. Finally, your program may successfully run but produce invalid data. This can occur through A/D overflows or missed data due to the trigger rate being too fast. In these cases, the red 'error' LED will flash but program execution will not be interrupted.

## CALIBRATION

There are only two pots which are used to calibrate the SR245. These pots control the gain of the unit's DAC for negative and positive outputs. To calibrate the unit you will need a 4 1/2 digit voltmeter with a dc accuracy equal to or better than 0.02%, and an ASCII RS232 computer terminal.

Before starting, record the switch settings and the DCE/DTE jumper location so that the unit may be easily returned to service following calibration. To start, establish communications between the SR245 and the computer terminal by selecting the same baud rates, parity bits and stop bits. For a 9600 baud terminal with no parity bit, 8 bit data word and 2 stop bits, set the SR245 switches as in the RS232 example of Figure 2. Also, make sure that the jumper header is in the DCE position (bottom socket, near the back panel RS232 connector). Connect the terminal to the SR245's

RS232 connector with a cable that has (at least) pins 2, 3, 5, 6 and 7. When the unit is plugged into the NIM crate and the crate's power turned on, the SR245 sign on message should appear on the terminal screen.

The object of the calibration is to set the gain of the DAC output for negative and then positive outputs. The calibration must be done in that order--negative first, then positive.

Connect the 4-1/2 digit voltmeter to analog output #1. Select the 20 VDC full scale range. Enter the commands as shown below (use the return key at the end of each line). In this procedure, the minus signs are important. [Comments are in square brackets]

```
OK->  I0           [No inputs, all outputs]
OK->  S1 = -0.1     [Set output #1 to -0.1 VDC]
```

Now, place the voltmeter in the relative position to null any offset which may be present (if your DVM does not have a relative button, you must remember the offset voltage: the object is to make the difference in the two readings equal to 10.000 VDC). Then send the command to set the output to -10.100V.

```
OK->  S1 = -10.1
```

Now, adjust P1, the top pot near the channel 3 input, so that the difference between the outputs reads -10.000 +/- .002 VDC.

Then send the command to set the output to +0.100V.

```
OK->  S1 = 0.1
```

Again, toggle the DVM's 'relative' button in order to null any offset. Then send the command to set the output to +10.100V.

```
OK->  S1 = 10.1
```

Now, adjust P2, the lower pot near channel #6 input BNC, so that the difference between the two output values is 10.000 +/- .002 VDC.

When the calibration is completed, return the switch settings and the DCE/DTE jumper to their original positions.

## CIRCUIT DESCRIPTION

The SR245 is a microprocessor based instrument which may be used to input and output analog and digital voltages. The analog I/O is via front panel BNC connectors (8 channels); digital I/O is via front panel BNC connectors (two bits) and by a printed circuit board mounted 20 pin dual in-line connector (8 bits of input and 8 bits of output with strobes). The SR245 may be interfaced to computers by either the IEEE-488 (also known as the GPIB or HPIB) or by the RS232. The communication interface is defined by setting the configuration switch on the circuit board.

Analog voltages may be read or set over  $\pm 10.2375$  VDC with a resolution of 2.5 mV, and an accuracy of +0.05%. Digital bits may be set, reset, tested and counted. One front panel bit is also used to synchronize data acquisition when the unit is programmed to acquire scans.

### MICROPROCESSOR AND DIGITAL I/O SR245 Schematic Page 1

The instrument uses a Z80-A CPU, U1. An 8K byte ROM, U2, is used for program storage and an 8K byte RAM, U3, is used for buffer memory. A power-on-reset circuit, C3 and U36, will restart the program whenever the unit is plugged into the NIM bin, or when the bin is turned on. The CPU is clocked at 4 MHz by a crystal control oscillator, U17. This clock is also divided down to generate other frequencies that are used by the communications circuits.

All of the I/O ports and VLSI devices are I/O mapped. U11, U18 and U19 serve as an I/O port decoder to select one device during I/O operations by the processor.

The 8 configuration switches are read through the octal buffer U12. (There are other hardware consequences of reading this port: the 12 bit DAC is cleared and the 8 bit offset DAC is loaded. More about this in the analog description.)

The 8253-5 programmable timer, U5, may be read, set and programmed by the Z80-A. This IC has three programmable counters: two are used to count digital pulses at the front panel BNC inputs, and the third is used to generate the x16 baud rate

clock for the RS232 UART. This baud rate is derived from the 4MHz clock input.

The front panel digital bits may be read through part of U13, an octal tristate buffer. U13 also reads the "compare" bit (used in A/D conversion) and the DCE/DTE bit (from the RS232 interface).

The 8 bit digital I/O port, whose connector may be accessed by a ribbon cable from the rear of the module, is read through U14, an octal buffer. The separate 8 bit output port is set by an output to U16, an octal latch and driver. An input from U14 will generate a 600 nS, active low strobe signal which indicates that the input port is being read. This signal, "RD I/O", appears on pin 2 of the 20 pin connector. An output to U16 will generate a 600 nS, active low strobe signal, "WR I/O", which appears on pin 19 of the 20 pin connector. This signal indicates that the new data has been written to the 8 bit output port.

An 8 bit output latch, U15, is used to set the front panel digital bits high, low or off. When off, the bit may be used as an input. To see how this works, notice that when both bits Q0 and Q1 of U15 are low, transistors Q3 and Q4 are both off, so digital input #1 is a high impedance input which may be read by U13 or counted by U5. If bit Q0 is set high, transistor Q4 will be forced into saturation, grounding the digital output #1 through the current limiting 50 ohm resistor, R7. If bit Q0 is set low, and bit Q1 set high, then digital output #1 is pulled high by the emitter of Q3. The output current is limited by R6 to provide short circuit protection.

Other output bits of U15 are used to control the green ACTIVITY LED, D2, the red ERROR LED, D3, and to control certain aspects of A/D and D/A conversion (the 'POLARITY' and 'SAMPLE' bits).

### ANALOG I/O SR245 Schematic Page 2

A single 12 bit digital-to-analog converter, U20, is used in all of the analog input and output operations. A precision 10.240 VDC reference, U38, is used as a voltage reference for the 12 bit DAC. The DAC is loaded by the Z80, 4 bits at a time. A final write operation is used to transfer the 12 bit input to the DAC's internal control register.

An op amp (the first 1/4 of U26) is used to convert the DAC's output current to a voltage. In addition to the current from the 12 bit DAC, current from an eight bit DAC, U32, is summed at U26. This eight bit DAC is used to correct for offset errors which can accumulate as analog voltages pass through buffers, inverters, S/H amps and comparators. These offsets are carefully measured after the unit is manufactured, and values to compensate for these offsets are placed in the unit's ROM. At the start of any A/D or D/A conversion, the 12 bit DAC is cleared and the appropriate offset byte is loaded into U32 to eliminate the unwanted offset.

The DAC voltage may be inverted or not inverted by the 2/4 of U26 under the control of the POLARITY bit. If the polarity bit is low, the 2/4 of U26 is a precision inverter; if the polarity bit is high, it is a precision unity follower.

The DAC voltage may be multiplexed to one of eight sample and hold output amplifiers [U27, U28] which can provide analog outputs to the front panel. The processor refreshes these S/H amplifiers every few mS.

For a channel to become an output, the appropriate switch in U24 or U25 must be closed. When the switch is closed, current from the particular S/H amp will pull the front panel output to the programmed level. The analog switch's channel resistance (a few hundred  $\Omega$ ) is effectively eliminated by the high open loop gain of the S/H amp. Analog outputs have a measured resistance of less than 1 $\Omega$ . The processor can select zero to eight of the channels as outputs.

## A/D CONVERSION

The processor uses the offset-corrected 12 bit DAC to do analog-to-digital conversions on the inputs by programmed successive approximations. The processor selects 1 of 8 channels by the analog multiplexer, U23. The selected voltage is buffered by the 3/4 of U26 and sampled by the S/H amplifier (U21 and 4/4 U26.) This analog sample is passed to the comparator, U31, to be compared with outputs from the DAC. The processor will cause the DAC output to converge to the analog sample with 13 tests of the COMPARE bit (sign plus 12 bits) by the method of successive approximations. The A/D conversion process takes about 300 $\mu$ S.

The ADC may be done on a channel whether it has been set as an input or an output. As inputs, the channel impedance is 1M $\mu$  (RN4). The input buffer amplifiers are protected from excessive inputs by the 10K $\mu$  resistors of RN3.

## COMMUNICATIONS INTERFACES

### SR245 Schematic Page 3

#### RS232 INTERFACE

The RS232 interface uses an 8251 UART (U4) to send and receive bytes in a bit serial fashion. Any standard rate between 300 and 19,200 baud may be selected with the configuration switches. The x16 baud rate clock to the UART comes from the 8253 programmable counter/timer. A 2 MHz clock to the UART is derived from the 4 MHz CPU clock by U9. The number of stop bits and parity format can also be specified by the configuration switches. The RS232 interface can be configured as either DTE (Data Terminal Equipment) or DCE (Data Communications Equipment) by moving a 16 pin jumper assembly between two sockets on the circuit board. When a data byte is received by the UART, the RxRDY output is set high, which interrupts the Z80A in order to remove the character from the UART's receiver data register.

#### GPIO INTERFACE

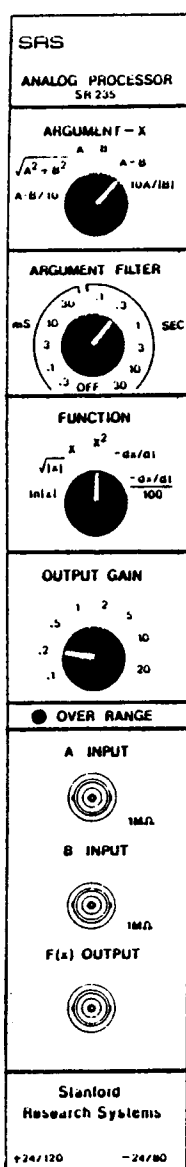
The interface between the SR245 and the GPIO is provided by the GPIO controller chip, U6, an MC68488. GPIO data and control lines are buffered by the bus drivers U7 and U8. The controller chip uses a 1MHz enable clock which is derived from the 4MHz CPU clock by U9. I/O transaction between the CPU and the controller chip must be synchronized to this 1MHz clock: U10 causes this synchronization to occur by making the CPU wait for up to 1 $\mu$ S whenever the controller chip is selected by the CPU.

The controller chip will interrupt the CPU whenever a transaction occurs on the GPIO which requires the CPU's intervention (such as the GPIO requesting data from the SR245). Most GPIO transactions, including transactions with other instruments, do not require the CPU's intervention. The SR245's address on the GPIO is set by the configuration switch when power is applied to the SR245.

## INTRODUCTION

The SR235 Analog Processor module provides an analog output,  $F(x)$ , which is formed from its analog inputs, A and B. The argument,  $x$ , is selected from A, B,  $A-B$ ,  $AxB/10$ ,  $10xA/|B|$ , or  $\sqrt{A^2+B^2}$ . This argument may be filtered with a time constant from 0.3 ms to 30 s, or left unfiltered. The function may be any of  $x$ ,  $x^2$ ,  $\sqrt{x}$ ,  $\ln|x|$ ,  $-dx/dt$  or  $(-dx/dt)/100$ . Finally, an output gain from 0.1 to 20 may be selected.  $5\ln(10A/B)$  for example, is available at the output.

The instrument provides many of the analog processing functions which are needed in an analog data acquisition system. The module may be used to ratio analog voltages, find peaks in experimental scans, linearize exponential decay curves, compress analog signals in order to increase dynamic range, or simply to amplify a signal.



## SPECIFICATIONS

### A and B Inputs

Input impedance of  $1M\Omega$ . Operating range of  $\pm 10$  Volts, protected to 100 Volts. Input offset voltage is less than 2mV.

### Argument X

Select A, B,  $\sqrt{A^2+B^2}$ ,  $A-B$ ,  $AxB/10$ , or  $10A/|B|$ .

### Gain

Selectable gain from 0.1 to 20 in a 1, 2, 5, sequence.

### $F(x)$ Output

$\pm 10$  Volts linear range. Output impedance is less than  $1\Omega$ . Short circuit limits at 20 mA.

### Over Range Indicator

Lights when input, output, or any intermediate signal is greater than  $\pm 10$  Volts.

### Frequency Range

$-dx/dt$  to 10 Hz,  $(-dx/dt)/100$  to 1 KHz,  $\sqrt{A^2+B^2}$  to 20 KHz, and all others from dc to 50 KHz.

### Accuracy

Gain 2%, rms sum 3%, difference 1%, multiplication 2% of full scale, division (with denominator  $>0.1$ ) 3% of full scale;  $\ln|x|$ ,  $x^2$ ,  $\sqrt{x}$  are accurate to  $\pm 20$  mV referenced to the input or at the output, whichever is less;  $-dx/dt$  and  $(-dx/dt)/100$  5%.

### Power

+24 V / 120mA, -24 V / 80mA. 5 watts total. Power from a NIM standard crate or from the Model SR280 mainframe.

### Mechanical

Single width NIM Standard per TID-20893. Dimensions 1.35" x 8.71" x 11.5".

### Warranty

One year parts and labor on materials and workmanship.

Figure 33 - SR235 Front Panel

## OPERATION

The SR235 Analog Processor performs a wide variety of operations on one or both of the two analog inputs labeled 'A' and 'B'. The functions 'F(x)' available at the output are:  $x$ ,  $x$  squared, log of the absolute value of  $x$ , square root of  $x$ , the time derivative of  $x$ , and the derivative of  $x$  divided by 100. The argument 'x' is chosen from A only, B only, the rms sum of A and B, the difference of A and B, the product of A and B divided by 10, and the quotient of A and the absolute value of B multiplied by 10. This argument may be filtered with a time constant from 0.3 ms to 30 s, or it may be left unfiltered. In addition, the output may be multiplied by a gain factor ranging from 0.1 to 20. Thus many complex operations may be performed simply by selecting among the various functions, arguments, and gains available at the front panel (Figure 33).

### FUNCTION OF CONTROLS AND INDICATOR

**ARGUMENT-X:** a six position switch for selecting the argument of the function provided to the F(X) OUTPUT. The arguments which may be chosen are: A, B,  $\sqrt{A^2+B^2}$ , A-B,  $A \times B/10$ , and  $10A/B$ .

**ARGUMENT FILTER:** a twelve position switch for selecting time constants from .3 ms to 30 s in a 1, 3, 10 sequence. When the selector is placed in the 'OFF' position the argument is left unfiltered.

**FUNCTION:** a six position switch for selecting the function provided to the F(X) OUTPUT. The functions which may be chosen are:  $x$ ,  $x^2$ ,  $\sqrt{x}$ ,  $\ln|x|$ ,  $-dx/dt$ , and  $-(dx/dt)/100$ .

**OUTPUT GAIN:** an eight position switch which allows a gain factor of .1, .2, .5, 1, 2, 5, 10, or 20 to be applied to the output.

**OVER RANGE:** a red LED which lights whenever the input, output, or any intermediate signal exceeds  $\pm 10$  V.

---

## OUTPUT CHARACTERISTICS

### LOAD

The Analog Processor output can drive loads as small as 1 K $\Omega$  to full scale, and its output impedance is less than 1  $\Omega$ .

### FREQUENCY RESPONSE

Most functions of the Analog Processor are capable of processing signals with frequencies up to at least 50 KHz. The frequency response of the rms adder rolls off at about 20 KHz. Bode plots for a few other functions are given in Figures 34-39. Figure 34 gives frequency response verses gain for arguments A, B, and A-B. The frequency response of the derivative circuits is plotted in Figure 35. A differentiator has a gain which is proportional to frequency, and so is sensitive to noise at high frequencies. In order to reduce this noise, the maximum gain of the differentiator circuits is limited to 100. For this reason  $-dx/dt$  acts as a differentiator only for frequencies below 10 Hz. Similarly,  $-(dx/dt)/100$  acts as a differentiator only for frequencies below 1 KHz. A INPUT frequency response versus B INPUT dc bias for the multiply and divide circuits are graphed in Figures 36 and 37 respectively. In Figure 37 we see that the divider's frequency response is diminished for small denominators. In Figure 38, small signal gain with a 1 V dc bias is plotted for the square and square root functions. Frequency response curves versus input bias are given for the log function in Figure 39.

### SOURCES OF ERROR

The linear range of inputs is  $\pm 10$  V. Input signals outside of this range will produce incorrect results, even if a gain is selected which would bring the output voltage within this range. The linear range for outputs is also  $\pm 10$  V. Thus output voltages outside of this range are probably incorrect, and it is up to the user to choose input signals or gains which bring the output within its linear range. The 'Over Range' indicator will light whenever the input, output, or any intermediate signal is outside of this linear range. On the high gain range, the input offset voltage is  $\pm 2$  mV, so that errors caused by this effect are less than 4% for inputs greater than 50 mV.

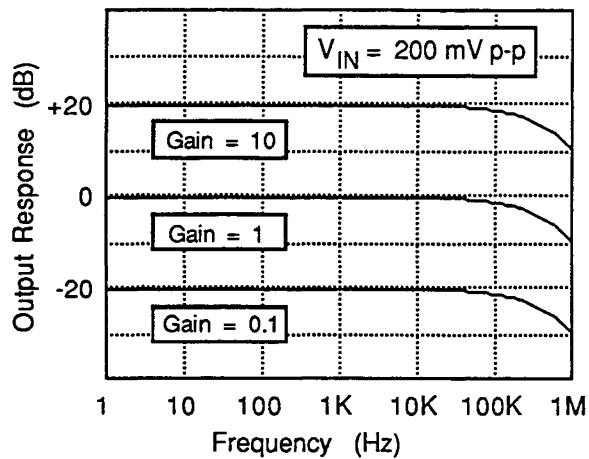


Figure 34 - Response of A, B, A-B

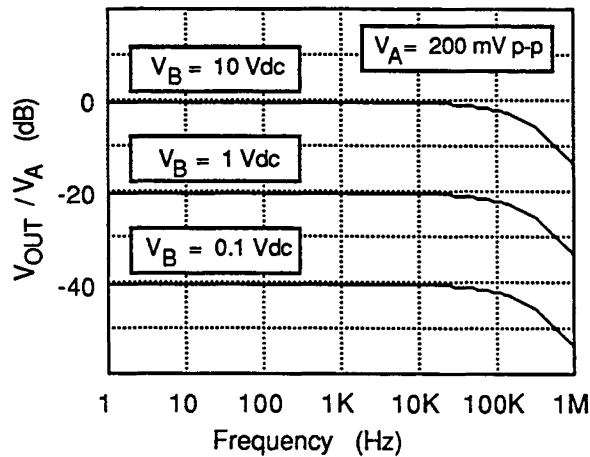
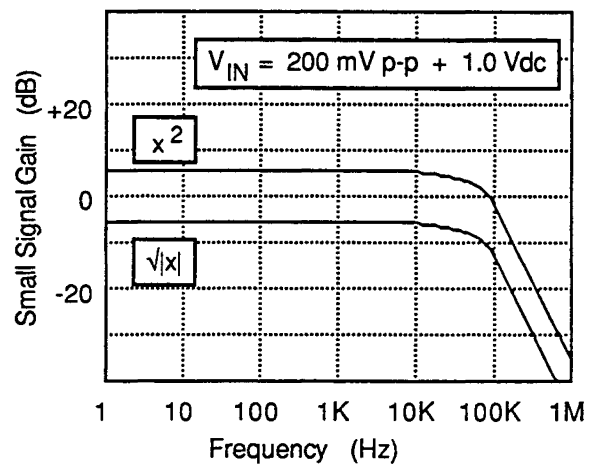
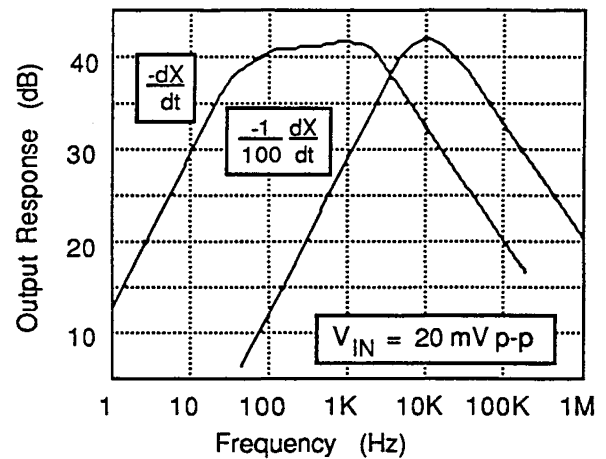
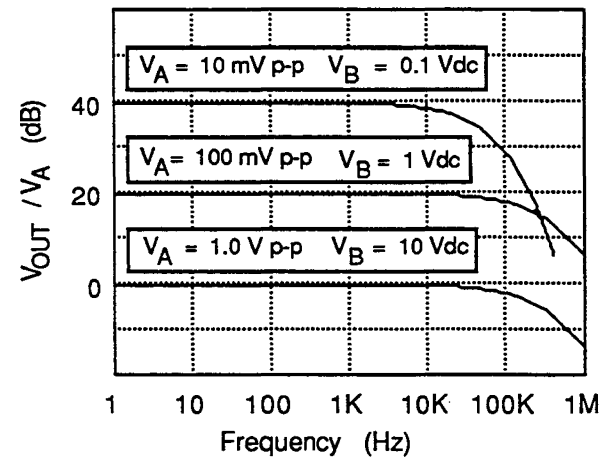
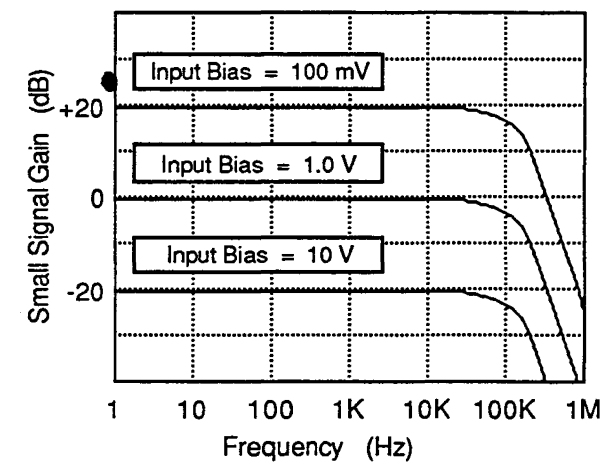
Figure 36 - Response of  $Ax B/10$ Figure 38 - Response of  $\sqrt{x}$  and  $x^2$ 

Figure 35 - Response of Derivatives

Figure 37 - Response of  $10A/|B|$ Figure 39 - Response of  $\ln|x|$

## TROUBLESHOOTING

If there are any difficulties in obtaining desired operation, the following checks may be useful. If no output is seen, check that the NIM crate is plugged-in, turned on, and providing +24 V and -24 V. Also check that the SR235 is firmly in place with mounting bolts screwed in.

## CALIBRATION

The SR235 Analog Processor is calibrated by adjusting the six internal trim pots which are labeled P1 through P6. To make these adjustments a regulated variable dc power supply and voltmeter are required, and the right side panel of the NIM module must be removed to access the trim pots. The output gain should be set to '1', and the argument filter should be off.

P1 is the multiplier input offset trim. Leaving 'B INPUT' open, apply 10 V to 'A INPUT', and connect 'F(X) OUTPUT' to the V meter. Place the argument switch to 'AxB/10' and adjust P1 until 'F(X) OUTPUT' reads 0.00 V.

The rms adder is calibrated by adjusting P2 and P3. With the power supply connected to 'A INPUT' and the voltmeter connected to 'F(X) OUTPUT' place the function switch to 'X' and adjust the input voltage until 500 mV is read at the output. Place the function switch to A2+B2, and adjust P2 until 500 mV is read at the output. Now connect the power supply to 'B INPUT', leaving 'A INPUT' open, and adjust P3 until 500 mV is read at the output.

The log function is calibrated by adjusting the log offset, P4, and the log scale, P5. Place the argument switch to 'A' and the function switch to 'X'. Connect the power supply to 'A INPUT' and the V meter to 'F(X) OUTPUT'. Adjust the input voltage until 1.00 V is read at the output. Place the function switch to 'ln(X)' and adjust P4 until the meter reads 0.00 V. Place the function switch to 'X' and adjust the input voltage until the meter reads 10.00 V. Place the function switch to 'ln(X)' and adjust P5 until the meter at the output reads 2.30 V.

P6 is used to calibrate the square function. With the power supply connected to 'A INPUT' and the voltmeter connected to 'F(X) OUTPUT' place the

function switch to 'X' and adjust the input voltage until 1.00 V is read at the output. Place the function switch to 'X2' and adjust P6 until 1.00 V is read at the output.

P7 is used to calibrate the square root function. With the power supply connected to 'A INPUT' and the voltmeter connected to 'F(X) OUTPUT' place the function switch to ' $\sqrt{|X|}$ ' and adjust the input voltage until 1.00 V is read at the output. Place the function switch to 'X2' and adjust P7 until 1.00 V is read at the output.

## CIRCUIT DESCRIPTION

Circuit descriptions for the SR235 will be given in terms of the elements which appear on the block diagram (Figure 40). Frequent references will also be made to the schematic diagram, given at the end of this manual.

### A AND B INPUT BUFFERS

These circuits consist of dual op amp U1 and resistors R1 - R4. 2/2 U1 is a unity follower that buffers A INPUT, R2 sets the input impedance to 1 M $\Omega$ , and R1 protects the op amp by limiting the input current. The B INPUT buffer circuit is identical to the A INPUT buffer circuit.

### A AND B ABSOLUTE VALUE

The absolute value of A is generated by dual op amp U2, diodes U19,5 - U19,8 and resistors R5, R6, and R19. The node where R5 and R6 are joined is the output. For A less than zero, the second half of U2 acts as an inverting amplifier with R19 and R6 setting the gain to unity. For A greater than zero, the first half of U2 acts as a unity follower. The absolute value of B is generated by dual op amp U3, diodes U19,1 - U19,4 and resistors R7, R8, and R20.

### A MINUS B

1/2 U4 and resistors R9-R12 form the difference circuit. To see how this circuit works, notice that 1/2 U4 is a non-inverting, times 2 amplifier for the signal, A/2, provided to pin 3. 1/2 U4 is also an inverting, unity gain amplifier for the signal B. Thus the output of 1/2 U4 is A-B.

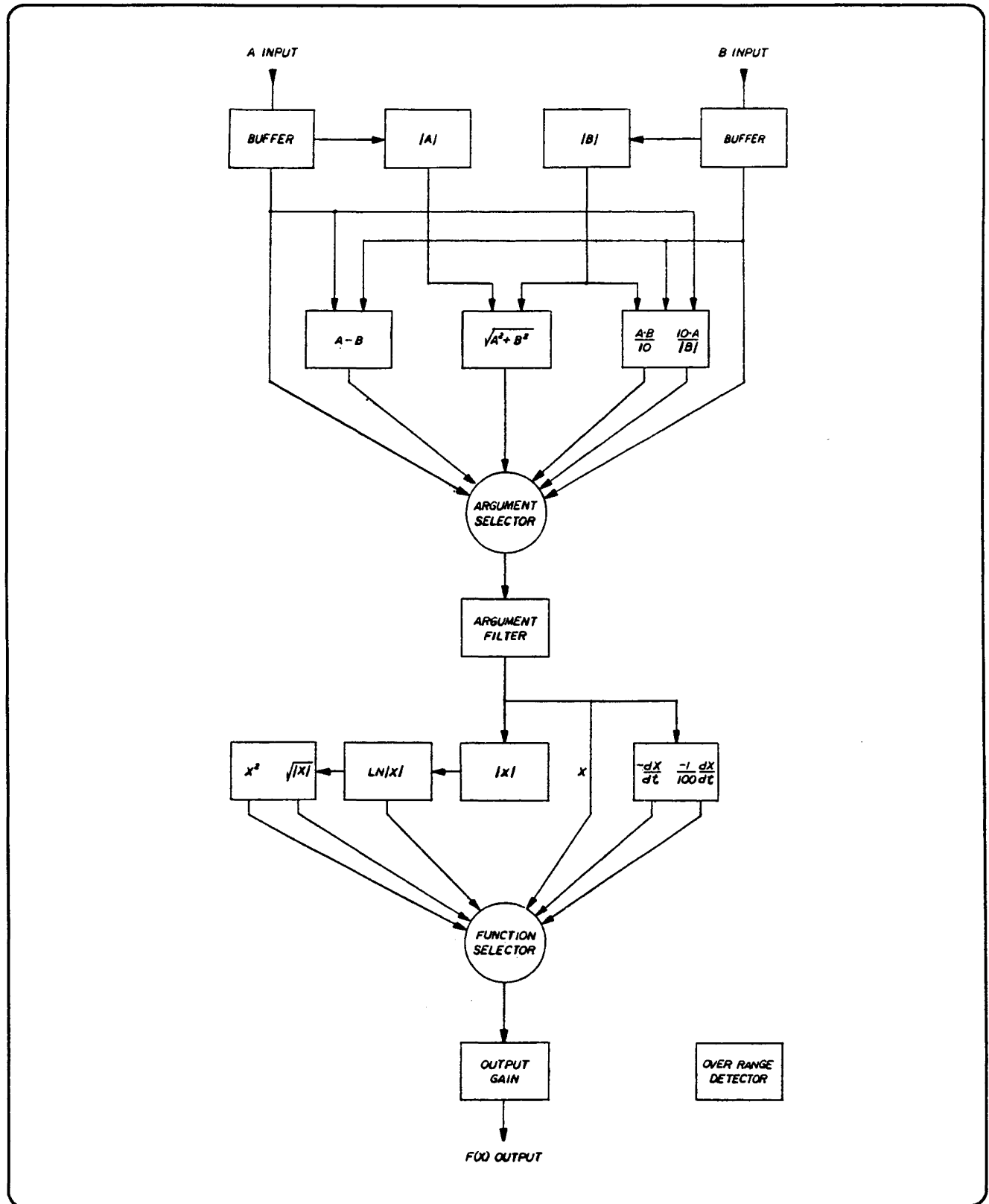


Figure 40 - SR235 Block Diagram



RMS SUM OF A AND B

The following components form the rms adder circuit: op amps 1/2 U5, 2/2 U5, 1/2 U6, 2/2 U6, 1/2 U11, and 1/4 U13; resistors R21-R33; capacitors C1, C2, and C25; diodes U20,6 and U20,7; pots P2 and P3; and transistor array U15. 1/4 U13, R25, and R26 generate a -5 V reference for the circuit. R21 and P2 convert the A input voltage to a current which equals the feedback current of op amp 1/2 U5. Due to the base-emitter characteristic of a transistor the voltage at U15 pin 10 is proportional to the log of the input voltage. 2/2 U5 and resistors R23 and R24 multiply the log of the input voltage by two, which is the square of the input. The current through U15 pin 1 is proportional to the exponential of one half this voltage when the B input is zero. The above description also holds for the B side of the rms adder circuit. The current through R27 is the sum of the currents through pins 1 and 5 of U15. 1/2 U11 and R27 convert this summed current into a voltage which equals the rms sum of the A and B input voltages.

MULTIPLICATION AND DIVISION

Both the multiply and divide functions are provided by U16 which is an AD534 precision IC multiplier. Besides A and B inputs, this circuit also requires the inverse of the absolute value of B. Op amp 2/2 U4, R13, and R14 invert the output of the absolute value of B circuit for this purpose. The switch configuration and resistors R15 and R16 provide necessary feedback paths. R17, R18, and potentiometer P1 provide the input offset trim. Instructions for making this adjustment are given in the calibration section.

ABSOLUTE VALUE OF X

The absolute value of X is used by the log, square, and square root functions allowing these functions to be defined for negative arguments. The dual op amp U8, diodes U20,1 - U20,4 and resistors R40-R42 belong to this circuit. The circuitry is identical to that of the absolute value of A.

LOGARITHM

The first two transistors of U14 form the core of the log circuit, which makes use of the log relationship

between  $V_{be}$  and  $I_c$  for a transistor. The first half of U9 and resistor R43 convert the input voltage into an input current  $I_{in}$  which becomes the collector current in the first transistor of U14. R45 and P4 determine the reference current,  $I_{ref}$ , which becomes the collector current in the second transistor of U14. The voltage at the base of this transistor, pin 4, is then given by,

$$V_t * \ln(I_{REF}/I_{IN})$$

where  $V_t$  depends on temperature and is nominally 26 mV at room temperature. Changing P4 changes the reference current, thus changing the log offset. The second half of dual op amp U9 changes the log scale by factors of two and will be discussed in the following paragraph. R49, R50, R51, P5, and the second half of dual op amp U11 take care of the final scale factor adjustment. Changing P4 changes this scale, and instructions for making this adjustment, as well as for P4, are given in the calibration section. R49 is a thermistor which compensates the scale factor for the temperature dependence of  $V_t$ . Diode U20,5 prevents positive voltages, caused by small values of the argument, from heating the thermistor thus preventing erroneous temperature compensation.

SQUARE AND SQUARE ROOT

An antilog circuit is used in conjunction with the log circuit to provide square and square root functions. The following relationships are used:

$$x^2 = \exp(2 * \ln(x)) \quad \text{and} \quad \sqrt{x} = \exp(\ln(x)/2)$$

The third and fourth transistors of U14, dual op amp U10, resistors R52-R54, and P6 comprise the antilog circuit. Its theory of operation is the same as that of the log circuit. P6 changes the reference current and therefore the antilog offset. The adjustment of P6 is explained in the calibration section. The gain of two required for the squaring operation is provided by the output of the second half of U10. The factor of one half required for the square root calculation is provided by R47 and R48. Temperature compensation is not required for the square and square root functions because the transistors are on the same monolithic chip and all thermal effects cancel.

### DERIVATIVES

The differentiation circuit consists of resistors R55-R58, capacitor C7, and the first half of dual op amp U7. These components are connected to form a differentiator whose time constant varies with the position of switch SW3. Ignoring for the moment the presence of R55 and R56, the gain of this amplifier is  $-wRC$  where  $w$  is the frequency of the input,  $R$  is either R57 or R58, and  $C$  is C7. Because its gain is proportional to frequency, this circuit is a differentiator. For  $'-dX/dt'$  we have  $RC=1S$ , and for  $'-(dX/dt)/100'$  we have  $RC=.01S$ . In order to reduce high frequency noise, resistors R55 and R56 limit the maximum gain to 100. The transition frequency, above which the gain is limited to 100, is given by the product,  $RC$ , where  $R$  is either R55 or R56 and  $C$  is C7. For  $'-dX/dt'$  this frequency is 16 Hz, and for  $'-(dX/dt)/100'$  this frequency is 1.6 KHz.

### OUTPUT GAIN

This circuit provides a gain factor, ranging from .1 to 20, to the signal at the output of the function selector. Op amp 2/2 U12, switch SW4, and resistors R59-R67 comprise this circuit. The op amp is in an inverting amplifier configuration with SW4 selecting the gain resistor.

### OUTPUT BUFFER

Op amp 1/2 U12, capacitor C8, and resistors R68 and R69 comprise the output buffer which is designed to keep the output stable regardless of the output load. This buffer can drive loads as small as  $1k\Omega$  to full scale.

### OVER RANGE DETECTOR

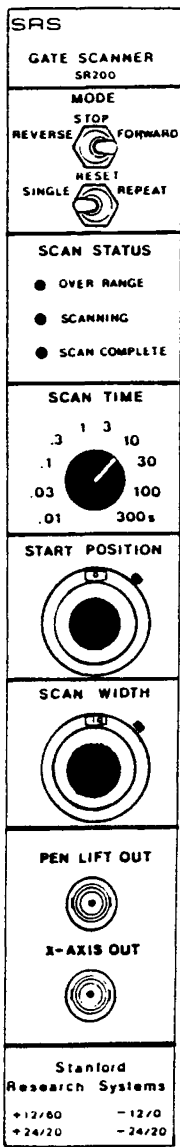
The following components are found in the over range detector circuit: diodes D22, U21,1 - U21,8 and U20,8; resistors R70-R80; op amps 2/4 U13, 3/4 U13, and 4/4 U13; capacitors C9 and C10; and LED D24. The five diodes U21,1 - U21,5 detect positive over ranges. The voltage at the common cathode of these diodes is .7 V less than the highest anode voltage. Op amp 4/4 U13 acts as a comparator which goes high whenever the diode common cathode voltage gets too high. Op amp 3/4 U13 is the comparator for negative over ranges. The time constant of R78 and C9 is the ignore time for the over range detector. Signals faster than 50 ms will not light the over range LED. The time constant of R79 and C10 determines the minimum time that the LED will remain lit.



INTRODUCTION

The SR250 Gated Integrator may be used to recover entire signal waveforms. A waveform is recorded by plotting the 'Average Output' vs. the 'Delay Multiplier' setting as the Delay Multiplier is slowly scanned. The SR200 Gate Scanner Module was designed to automate this procedure. This module provides the signals needed to scan the SR250's delay multiplier (to scan the sample gate through the waveform) and to control an X-Y chart recorder or strip chart recorder or oscilloscope.

When connected, the SR200 over-rides the delay multiplier dial on the SR250. The SR200 electronically scans the delay multiplier over a range specified by 10-turn dials on the SR200's front panel. Single or repeated scans may be done in the forward or reverse direction over any portion of the waveform. Scan times from 10 ms to 6 minutes may be selected. The X-axis output always ramps between 0 and 10 Vdc, regardless of the dial settings, providing a convenient interface to pen recorders and oscilloscopes.



SPECIFICATIONS

CONTROLS

- Reverse/Stop/Forward
- Single/Reset/Repeat
- Scan Time
- Start Position
- Scan Width

- Selects the scan direction or stops the scan.
- Selects single or repeated scans or resets to start.
- Selects time to complete one scan.
- Specifies the smallest Delay Multiplier in the scan.
- Specifies the range of Delay Multipliers in the scan.

INDICATORS

- Over Range LED
- Scanning LED
- Scan Complete LED

- Indicates that the delay multiplier exceeds 10.0.
- Indicates that a scan is in progress.
- Indicates that a single scan has been completed.

OUTPUTS

- Control Voltage
- Pen Lift
- X-Axis

- Rear panel output connects to the SR250 External Delay Multiplier Input. This output has an impedance of less than 1  $\Omega$  and current limits at 20 mA.
- Logic Signal to lift chart recorder pen or blank an oscilloscope trace.
- Analog voltage output scans between 0 and 10.0 Vdc regardless of the start position and scan width dial settings.

GENERAL SPECIFICATIONS

- Power Supplies
- Mechanical
- Warranty

- +24V/20mA, +12V/80mA, 112V/0mA, 124V/20mA. 2 Watts total. Power from a NIM standard crate or from the SRS mainframe Model SR280.
- Single Width NIM standard module per TID-20893.
- Dimensions 1.35"x8.714"x11.5".
- 1 year parts and labor on materials and workmanship.

Figure 41 - SR200 Front Panel

## OPERATION

The SR200 Gate Scanner gives the SR250 Gated Integrator and Boxcar Averager the capability of operating in a scanning gate mode. Sampled waveforms may be viewed on either a chart recorder or an oscilloscope. Sample averaging may be used to reduce background noise.

## FUNCTION OF CONNECTORS

**CONTROL VOLTAGE OUT:** provides a ramp or saw-tooth waveform to the SR250's 'External Delay Control'. The 'Start Position', 'Scan Width', and 'Scan Time' controls determine the shape of this waveform, hence the details of how the gate delay is scanned. This connector is located on the rear panel of the SR200.

**X-AXIS OUT:** a 0 to 10 Volt ramp which connects to the x-axis of a chart recorder or oscilloscope.

**PEN-LIFT OUT:** connects to a chart recorder pen-lift or to an oscilloscope blanking input. A +3.6 Volt pulse indicates a retrace in progress. Removing internal jumper J1 allows the complement of this signal to be output.

## FUNCTION OF CONTROLS

**REVERSE/STOP/FORWARD:** determines the direction of the scan, or stops a scan in progress, holding the gate in place.

**SINGLE/RESET/REPEAT:** determines whether a single scan or a repeat scan will be performed, or whether the gate should be reset to its start position.

**SCAN TIME:** a ten position switch for selection of a scan duration which ranges from 10 milliseconds to 300 seconds.

**START POSITION:** a ten-turn potentiometer for determining the starting delay of a forward scan, or the final delay of a reverse scan. The reading on the ten-turn dial may be multiplied by the delay range selected on the SR250 to give the actual starting delay.

**SCAN WIDTH:** a ten-turn potentiometer for determining the range of delays over which the

scan will be taken. The reading on the ten-turn dial may be multiplied by the delay range selected on the SR250 to give the actual scan width.

## FUNCTION OF INDICATORS

**OVER RANGE:** a red LED which indicates when the sum of 'Start Position' and 'Scan Width' total to a delay multiplier greater than 10.

**SCANNING:** an amber LED which indicates that a single or repeat scan is in progress.

**SCAN COMPLETE:** a green LED which indicates that a single scan is finished.

## SET-UP

The 'Control Voltage' output on the rear panel of the Gate Scanner must be connected to the 'External Delay Control' on the rear of the Gated Integrator. This is the only connection between these two devices. The 'Delay Multiplier' on the front of the Gated Integrator is now inactive, its function being assumed by the Gate Scanner. 'X-Axis Out' on the Gate Scanner is connected to the x-axis of a chart recorder or to the 'X' input of an oscilloscope in 'X-Y' mode. 'Averaged Output' on the Gated Integrator is connected to the y-axis of a chart recorder or to the 'Y' input of an oscilloscope in 'X-Y' mode. Finally, 'Pen Lift Out' on the Gate Scanner is connected to the pen lift input of a chart recorder or to the blanking input of an oscilloscope.

## OPERATING INSTRUCTIONS

Set the Gate Scanner toggle switches to 'Stop' and 'Reset'. Adjust 'Start Position' to the delay multiplier that corresponds to the beginning of the desired scan. Adjust 'Scan Width' to the delay multiplier that corresponds to the width of the desired scan. Select a scan time. Select a 'Forward' or 'Reverse' scan. Select a 'Single' or 'Repeat' scan. An alternative way to adjust the 'Start Position' and 'Scan Width' is to view the signal to be scanned and the gate simultaneously on an oscilloscope. Set the toggle switches to 'Forward' and 'Reset', and adjust 'Start Position' until the gate overlaps the portion of the signal where the scan is to begin. Then set the toggle switches to 'Reverse' and 'Reset', and adjust 'Scan Width' until the gate overlaps the portion of the signal where the scan is to end.

## TROUBLESHOOTING

If there are any difficulties in obtaining desired operation, the following checks may be useful. If no output is seen, check that the NIM crate is plugged-in, turned on, and providing  $\pm 24$  Volts and  $\pm 12$  Volts. Also check that the SR200 is firmly in place with mounting bolts screwed in.

## CALIBRATION

The SR200 Gate Scanner is calibrated by adjusting a single internal trim pot. Measure the voltage at pin 8 of U1 and adjust the trim pot until 10.00 volts is read.

## CIRCUIT DESCRIPTION

### ANALOG CIRCUITRY

The 'Control Voltage' output of the gate scanner is a ramp with variable offset, height, and slope. Ramps are generated by integrating a constant voltage,  $V_{in}$ , according to the following relation:

$$V_{out} = -(V_{in}/RC) \cdot t$$

The integrator is the first op amp of quad op amp U1. The output of this op amp is a ramp between 0 and +10 Volts. Offsets and variations in height are added to this ramp later. An analog multiplexer, U9, selects among four constant voltages,  $V_{in}$ , to be integrated, and the 'Scan Time' selector switch determines which resistors and capacitors will be used for this integration.

U9 is a dual 4 channel multiplexer. Inputs to the second half of this multiplexer are  $\pm 5$  Volts with signs being determined by the upper and lower limit sense circuits. The output is fed to R10 to form the retrace ramp. Inputs to the first half of U9 are  $\pm 0.44$  Volts. Resistive dividers composed of R1, R2, R3, and R4 provide these levels to the multiplexer. The output is fed to resistors R5, R6, R7, R8, and R9 to form the main ramp.

The upper and lower limit sense circuits determine when the output of the integrator is outside of the 0 to 10 Volt range. The lower limit sense circuit is comprised of the first op amp of quad op amp U2,

resistors R12, R14, R16, and capacitor C4. The output of this circuit is +5 Volts unless the ramp voltage goes below zero, after which the output is -5 Volts. The upper limit sense circuit is comprised of the second op amp of U2, resistors R11, R13, R15, and capacitor C3. This circuit compares the ramp voltage with a 10 volt reference. It outputs +5 Volts if the ramp is above 10 Volts and -5 Volts otherwise.

The logic level translation circuitry converts these  $\pm 5$  Volt signals to 5/0 Volt signals which are then compatible with the logic circuits. The upper limit translation circuit consists of the second op amp of U1, and resistors R17, R19, R21, R23, and R25. Its output is 5 Volts when the upper limit is sensed and 0 otherwise. The lower limit translation circuit consists of the fourth op amp of U1, R18, R20, R22, R24, and R26. Its output is 5 Volts when the lower limit is sensed and 0 otherwise.

The 10 Volt reference consists of the third op amp of U1, trim pot P3, resistors R29, R30, and capacitor C8. P3 is adjusted to make the output equal to 10.00 Volts.

The 0 to 10 Volt ramp becomes the 'X-Axis' output after passing through an output buffer consisting of the first op amp of quad op amp U3, resistors R38, R39, and capacitor C6. This buffer keeps the output stable for loads greater than 2K $\Omega$ .

Offset and height modifications are made to the 0 to 10 Volt ramp which then becomes the 'Control Voltage' output. The 0 to 10 Volt ramp is reduced in height by the 'Scan Width' potentiometer, P2, and buffered by the fourth op amp of U2 which is a unity follower. The 'Start Position' potentiometer, P1, provides a dc level between 0 and 10 Volts, which is buffered by the third op amp of U2. These 'Start Position' and 'Scan Width' signals are then added together by the second op amp of U3 and R31-R34. The output of this adder becomes the 'Control Voltage' after it passes through an output buffer consisting of the fourth op amp of U3, resistors R40, R41, and capacitor C7.

The 'Over Range' indicator lights up when the output of the adder exceeds 10 Volts. The third op amp of U3 compares the output of the adder with the 10 volt reference and outputs +13 Volts if the adder is greater than 10 Volts, and -13 Volts otherwise. R35 and R36 reduce these levels to

$\pm 5$  Volts. The voltage at the cathode of D1 is +5 Volts when there is an over range and zero otherwise. These +5 Volt signals charge up C5 which is bled off by R37 with a time constant of .1 seconds, thus stretching the duration of short pulses. The fourth gate of quad exclusive OR U7 acts as an impedance buffer to prevent current into the base of Q4 from bleeding C5 too fast. A 5 volt level at the base of Q4 turns this transistor on and lights up the 'Over Range' LED.

### DIGITAL CIRCUITRY

The inputs to the digital circuitry are the 'Reverse/Stop/Forward' & 'Single/Reset/Repeat' toggle switches on the front panel, and the upper and lower limit signals from the analog circuitry: UPPER and LOWER. Outputs from the digital circuitry are the 'Scanning' and 'Scan Complete' indicators, the 'Pen Up' output, and the control signals for the analog multiplexer: HOLD, SEEK, and DIRECTION. Figure 42 gives the state of each control signal when the 'Gate Scanner' is performing various functions.

#### REVERSE SINGLE SCAN

Toggle Switches		Control Lines										Indication	
<u>Rev / Stop / For</u>	<u>Sing / Res / Rep</u>	<u>FOR</u>	<u>SING</u>	<u>UPP</u>	<u>LOW</u>	<u>PEN</u>	<u>END</u>	<u>HOLD</u>	<u>SEEK</u>	<u>DIR</u>		<u>S.</u>	<u>S.C.</u>
x	x	0	Q	1	0	0	0	0	1	1			
x	x	0	1	0	0	0	0	0	0	0		x	
x	x	0	1	0	1	1	1	0	1	1			x

#### FORWARD SINGLE SCAN WITH STOP

Toggle Switches		Control Lines										Indication	
<u>Rev / Stop / For</u>	<u>Sing / Res / Rep</u>	<u>FOR</u>	<u>SING</u>	<u>UPP</u>	<u>LOW</u>	<u>PEN</u>	<u>END</u>	<u>HOLD</u>	<u>SEEK</u>	<u>DIR</u>		<u>S.</u>	<u>S.C.</u>
x	x	1	Q	0	1	0	0	0	1	0			
x	x	1	1	0	0	0	0	0	0	1		x	
x	x	1	1	0	0	0	0	1	0	1		x	
x	x	1	1	0	0	0	0	0	0	1		x	
x	x	1	1	1	0	1	1	0	1	0			x

#### FORWARD REPEAT SCAN

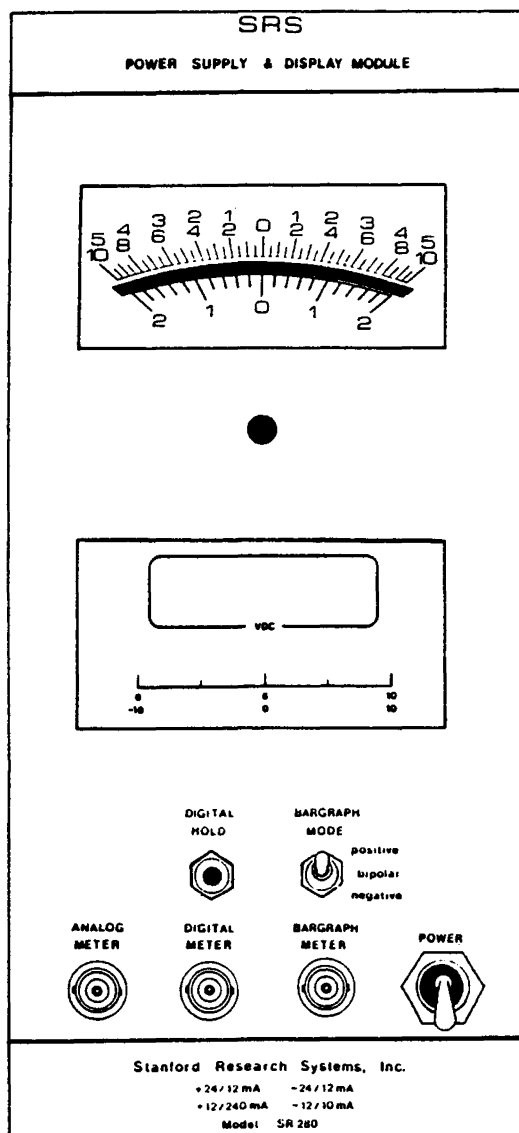
Toggle Switches		Control Lines										Indication	
<u>Rev / Stop / For</u>	<u>Sing / Res / Rep</u>	<u>FOR</u>	<u>SING</u>	<u>UPP</u>	<u>LOW</u>	<u>PEN</u>	<u>END</u>	<u>HOLD</u>	<u>SEEK</u>	<u>DIR</u>		<u>S.</u>	<u>S.C.</u>
x	x	1	Q	0	1	0	0	0	1	1			
x	x	1	0	0	0	0	0	0	0	1			
x	x	1	0	1	0	1	0	0	1	1		x	
x	x	1	0	0	1	0	0	0	0	1		x	
x	x	1	0	0	0	0	0	0	0	1		x	
x	x	1	0	1	0	1	0	0	1	1			

Figure 42 - Gate Scanner Logic Table

## INTRODUCTION

The SR280 System Mainframe provides power to SRS modules and has three displays for monitoring outputs. This mainframe is NIM compatible so that modules from other manufacturers may be used in the SRS system. NIM refers to the nuclear instrument module standard developed by the AEC NIM committee in 1964 and described in report TID-20893. In the

SR280 System Mainframe, the three rightmost slots of a standard NIM bin are filled by the display module and unregulated power supply. This leaves 9 slots available for other NIM modules. The dc power supply regulators are mounted on a heat sink on the rear of the mainframe. Regulated + and - 12 Vdc, regulated + and - 24 Vdc, and 120 Vac are bussed to each of the slots. The Mainframe may be mounted on a 19" rack, but also has feet for table top use.



## SPECIFICATIONS

Input Voltage	120, 220 Vac
Input Voltage Range	120: +8% -8% of nominal 220: +10% -6% of nominal
Input Current	3Amps max. at 120 Vac
Output Voltages	$\pm 12$ Vdc, $\pm 24$ Vdc, 120 Vac
Output Currents	2 Amps $\pm 12$ Vdc 1 Amp $\pm 24$ Vdc 1 Amp 120 Vac
Output Voltage Adjustment	1%
Adjustment Accuracy	.05%
Load Regulation	.1% ( $\pm 12$ Vdc) .3% ( $\pm 24$ Vdc)
Line Regulation	.1%
Output Impedance	< .3 $\Omega$
Combined Noise and Ripple	< 3 mV peak to peak
Temperature Coefficient	< 200 ppm/ $^{\circ}$ C
Display Inputs	1 M $\Omega$ input impedance $\pm 10$ Volt operating range 100 Volt protection
Analog Meter	zero center, 2% accuracy
Digital Meter	3-1/2 digit, .25% accuracy
Bargraph Meter	20 segments, 2% accuracy, 5% resolution
Mechanical	16.875" x 8.714" x 13.0"
Warranty	1 year parts and labor on materials and workmanship.

Figure 43 - SR280 Front Panel



The display module features three types of display meters. The analog meter has a high torque, 100°, taut band d'Arsonval movement. It is a zero center,  $\pm 10$  dc Voltmeter with 2% accuracy. The digital meter uses dual slope integration to provide readings accurate to .25%. This meter samples dc voltages between + and - 10 Volts at a rate of 3 readings per second, and has a 3-1/2 digit seven segment LED display. The 'Digital Hold' button may be used to hold the digital meter's reading. The bargraph meter is best suited for displaying rapidly changing data. It has a bandwidth of 50 KHz, 2% accuracy, and 5% resolution. The bargraph has three display modes: 'positive' for 0 to 10 Volts, 'bipolar' for -10 to +10 Volts, and 'negative' for 0 to -10 Volts. In the 'positive' and 'negative' modes, the display is a bargraph so that all LED's from the reading to zero light up. In the 'bipolar' mode, a dot display is used so that only the LED corresponding to the voltage reading lights up.

## TROUBLESHOOTING

If there are any difficulties in obtaining desired operation, the following checks may be useful. Check that the line cord is in place, the display module is firmly attached to the chassis, the fuses are intact, and the power switch is in the up position.

## CALIBRATION

### SUPPLY VOLTAGES

The dc output voltages should be calibrated with a load about equal to half of full load, and only after the supply has warmed up. Each supply may be calibrated individually by turning the appropriate trim pot and measuring the output voltage with a Voltmeter. The trim pots can be accessed by removing the four mounting screws on the back of the heatsink.

### DISPLAYS

The analog meter can be zeroed by turning the front panel adjust screw until the needle is lined up with zero, pointing straight up. This adjustment must be made when there is no voltage connected

to the input. The digital meter is calibrated by applying 10 Volts to the input and adjusting the internal trim pot until 10.00 Volts is read on the display. The trim pot may be accessed by sliding open the right side panel of the Display Module. The bargraph meter cannot be calibrated.

## CIRCUIT DESCRIPTION

### POWER SUPPLY

The unregulated power supply consists of two dual complementary full wave center-tapped rectifier circuits. The transformer has a dual primary which can be wired in parallel or series for 120 or 220 Vac respectively. In some models the primary has a tap for 100 Vac. In all cases, 120 Vac is wired to the bin supplies through its own 1 Amp fuse. The transformer has two center-tapped secondaries of 28 and 48 Vac to provide unregulated 20 and 32 Vdc to the regulator circuit.

The regulator circuits for +12, +24, and -24 V are essentially the same, so only the +24 V supply will be described. The output of U1 is 1.25 V between pins 1 and 3. R1, R2, and P1 bring the voltage between the output and ground to about 24 V. Adjusting P1 changes this output voltage. C1 and C3 are bypass capacitors which improve output stability. C2 improves the ripple rejection of the circuit. D1 protects the regulator from discharge of C3 when the input is shorted, and D2 protects the regulator from discharge of C2 when either the input or the output is shorted.

The circuit for the -12 V supply is the same as for the other supplies except that op amp U5 has been added to improve stability. Its presence assures that variations in current at pin 1 of U4 will not affect the output voltage.

### DISPLAY MODULE

The analog meter circuit consists of the meter movement, an op amp, and two resistors. Op amp 2/4 U4 acts as a buffer, R22 sets the input impedance to 1 M $\Omega$ , and R21 protects the op amp by limiting its input current.

The digital meter circuit consists of an ICL7117 analog to digital converter connected to a 3-1/2 digit display. Resistors R4 and R5 scale down the

input by a factor of ten and provide 1 M $\Omega$  of input impedance. P1 is a 20-turn trim pot used to calibrate the output. SW1 is the digital hold button. R9 turns on the decimal point LED.

The twenty LED segments of the bargraph meter are controlled by two dot/bar display driver IC's. These two IC's are configured to read voltages ranging from 0 to 2.5 V. A set of op amps is used to convert the three front panel modes to this range. The mode is selected at switch SW2-1. Resistors R10 and R11 divide the input by 4 and insure a 1M $\Omega$  input impedance. Op amp 3/4 U4

buffers the input and provides the proper voltage for the positive mode to position 1 of SW2-1. Op amp 4/4 U4 inverts the previous voltage for the negative mode at position 3 of SW2-1. Op amp 1/4 U4 amplifies the reference voltage of U2 to 2.5 V, so that the voltage at the node between R14 and R15 is in the correct range for the bipolar mode. The outputs of 3/4 U4 and 4/4 U4 override this voltage unless the center position of SW2-1 is selected. Switches SW2-2 and SW2-3 select whether a dot or bargraph display will be used in each mode. If jumpers J1 and J2 are cut, all three modes will have a dot display.

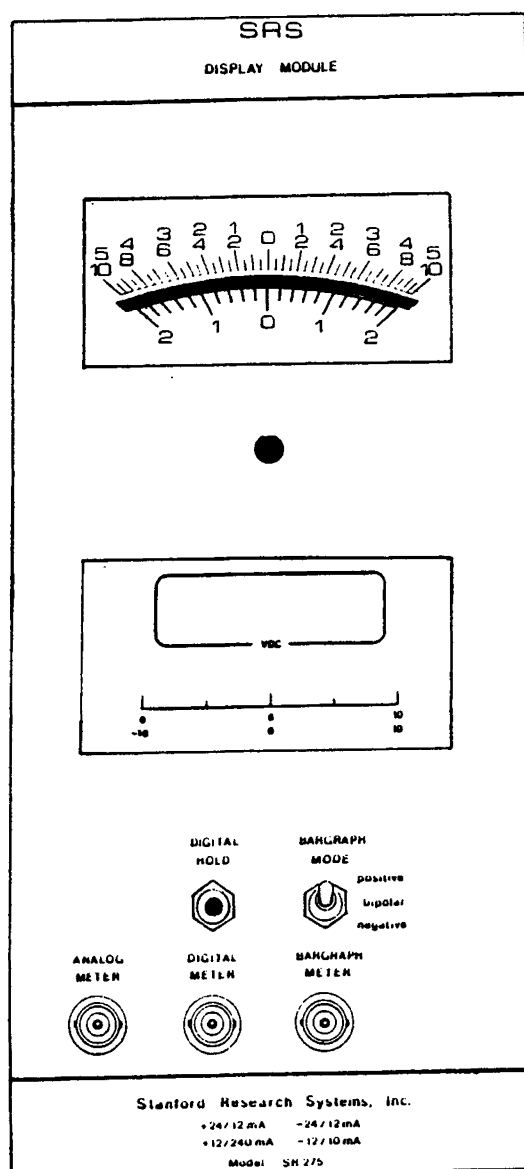
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## INTRODUCTION

The display module features three types of display meters. The analog meter has a high torque, 100°, taut band d'Arsonval movement. It is a zero center,  $\pm 10$  dc voltmeter with 2% accuracy. The digital meter uses dual slope integration to provide readings accurate to .25%. This meter samples dc voltages between + and - 10 Volts at a rate of 3 readings per second, and has a 3-1/2 digit seven segment LED display. The 'Digital Hold' button may be used to hold the digital meter's reading.

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## SPECIFICATIONS

Input Impedance	1 M $\Omega$
Operating Range	-10 to +10 Volts
Protection	100 Volts
Analog Meter	zero center, 2% accuracy
Digital Meter	3-1/2 digit, .25% accuracy
Bargraph Meter	20 segments, 2% accuracy, 5% resolution
Power	NIM standard crate +24 / 12 mA, -24 / 12 mA +12 / 240 mA, -12 / 10 mA 3.6 Watts total
Mechanical	4.05" x 8.714" x 11.5"
Warranty	1 year parts and labor on materials and workmanship.

Figure 44 - SR275 Front Panel

## TROUBLESHOOTING

If there are any difficulties in obtaining desired operation, the following checks may be useful. If no output is seen, check that the NIM crate is plugged-in, turned on, and providing  $\pm 24$  Volts and  $\pm 12$  Volts. Also check that the SR275 is firmly in place with mounting bolts screwed in.

## CALIBRATION

The analog meter can be zeroed by turning the front panel adjust screw until the needle is lined up with zero, pointing straight up. This adjustment must be made when there is no voltage connected to the input. The digital meter is calibrated by applying 10 Volts to the input and adjusting the internal trim pot until 10.00 Volts is read on the display. The trim pot may be accessed by sliding open the right side panel of the Display Module. The bargraph meter cannot be calibrated.

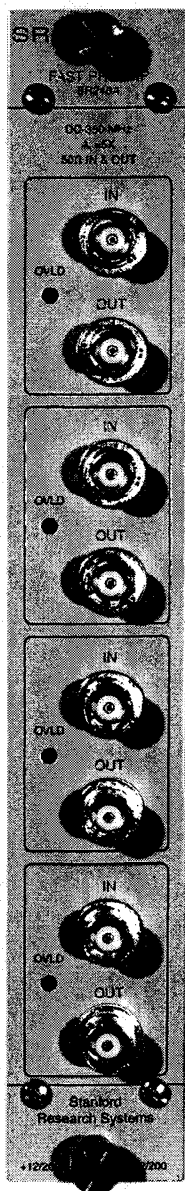
## CIRCUIT DESCRIPTION

The analog meter circuit consists of the meter movement, an op amp, and two resistors. Op amp 2/4 U4 acts as a buffer, R22 sets the input impedance to 1 M $\Omega$ , and R21 protects the op amp by limiting its input current.

The digital meter circuit consists of an ICL7117 analog to digital converter connected to a 3-1/2 digit display. Resistors R4 and R5 scale down the input by a factor of ten and provide 1 M $\Omega$  of input impedance. P1 is a 20-turn trim pot used to calibrate the output. SW1 is the digital hold button. R9 turns on the decimal point LED.

The twenty LED segments of the bargraph meter are controlled by two dot/bar display driver IC's. These two IC's are configured to read voltages ranging from 0 to 2.5 V. A set of op amps is used to convert the three front panel modes to this range. The mode is selected at switch SW2-1. Resistors R10 and R11 divide the input by 4 and insure a 1 M $\Omega$  input impedance. Op amp 3/4 U4 buffers the input and provides the proper voltage for the positive mode to position 1 of SW2-1. Op amp 4/4 U4 inverts the previous voltage for the negative mode at position 3 of SW2-1. Op amp 1/4 U4 amplifies the reference voltage of U2 to 2.5 V, so that the voltage at the node between R14 and R15 is in the correct range for the bipolar mode. The outputs of 3/4 U4 and 4/4 U4 override this voltage unless the center position of SW2-1 is selected. Switches SW2-2 and SW2-3 select whether a dot or bargraph display will be used in each mode. If jumpers J1 and J2 are cut, all three modes will have a dot display.

## SR240A Quad Fast Amplifier



### DESCRIPTION

The SR240A is a four-channel, 350MHz bandwidth, dc coupled, 50 $\Omega$  amplifier with a gain of 5 $\times$  (or +14dB) in a NIM module. Two, three or four channels may be cascaded for gains of 25 $\times$ , 125 $\times$ , or 625 $\times$ , (+28dB, +42dB, or +56dB.) The unit uses BNC connectors for inputs and outputs. A NIM mainframe provides power to the unit.

The full scale input is  $\pm 200\text{mV}$ . The input noise is typically  $5.2\text{nV}/\sqrt{\text{Hz}}$ . The output is linear over  $\pm 1\text{V}$  and should be terminated into a 50 $\Omega$  load. Output rise and fall times are 1.3ns. The output will recover from a 10 $\times$  full scale overload in 3ns. The unit is protected from  $\pm 50\text{V}$ , 1 $\mu\text{s}$  input overloads.

The unit is powered by  $\pm 12\text{Vdc}$  from the NIM mainframe. There are four LEDs on the front panel which indicate when the output signal for the corresponding channel is outside its linear range, typically  $\pm 1.3\text{Vdc}$ . Brief overloads (<5ns) trigger a 10ms flash.

### OPERATION

The input impedance for each channel is 50 $\Omega$ . The dc input voltage must be limited to  $\pm 4\text{V}$  to avoid damaging the amplifier front-end. The amplifier is internally protected from 50V transients of 1 $\mu\text{s}$  duration. The 50  $\Omega$  input impedance is intended to terminate 50 $\Omega$  coaxial cable such as RG-58.

The amplifiers perform well when cascaded due to their high input return loss and flat frequency response characteristics. Referenced to the input, the broadband noise (1Hz to 300MHz) is  $80\mu\text{V}_{\text{rms}}$ . Peak-to-peak noise is typically 5 $\times$  the RMS value and so one would expect to see about  $10\text{mV}_{\text{pp}}$  at the output of two cascaded amplifiers,  $50\text{mV}_{\text{pp}}$  at the output of three cascaded amplifiers, and  $250\text{mV}_{\text{pp}}$  at the output of four cascaded amplifiers.

**SR240A SPECIFICATIONS**

Specification	Min	Typ	Max	Units
<b>Inputs (driven by 50 source)</b>				
Input signal level	-200		+200	mV
Impedance	49.5	50	50.5	$\Omega$
Return loss		32		dB
Offset	-500	0	+500	$\mu$ V
Offset drift	-10		+10	$\mu$ V/ $^{\circ}$ C
Bias current (note 1)		3	10	$\mu$ A
Protection (dc)	-4		+4	Vdc
Protection (1 $\mu$ S transient)	-50		+50	V
Recovery time (10 $\times$ FS overload)		3		nS
Noise (10Hz)		22		nV/ $\sqrt$ Hz
Noise (100Hz)		8.6		nV/ $\sqrt$ Hz
Noise (> 1kHz)		5.2		nV/ $\sqrt$ Hz
Noise (1Hz to 300MHz BW)		80		$\mu$ Vrms
Crosstalk (CH1 out to CH2 in)		-61		dB
Crosstalk (CH2 out to CH1 in)		-82		dB
<b>Amplifier</b>				
Gain (note 2)	4.95	5.00	5.05	V/V
Bandwidth (-3dB)		350		MHz
Rise/fall time		1.3		nS
Propagation delay		2.7		nS
<b>Outputs (driving 50 )</b>				
Source impedance	49.5	50	50.5	$\Omega$
Linear operation	-1.0		+1.0	V
Overload level	-1.3		+1.3	V
Limit level	-1.6		+1.6	V
<b>General</b>				
Number of Channels		4		
Operating temperature	0		40	$^{\circ}$ C
Supply voltage		$\pm$ 12		Vdc
Supply current		160		mA
Dimensions	1.35"	8.714"	11.5"	W $\times$ H $\times$ D

**NOTES:**

1. The input bias current flows out of the unit, creating a positive offset of about 150 V on the 50 $\Omega$  input termination. This offset will be affected by the dc impedance of the source that is connected to the input.
2. Amplifier gain is calibrated by applying a known current to the input and measuring the voltage into a high impedance load. The gain is adjusted so that a 1mA source applied to the input produces a 500mV voltage at the unloaded output.

## CALIBRATION

The purpose of the calibration is to verify operation of the unit and:

1. Adjust the high frequency compensation for best pulse response.
2. Adjust the offset to null the dc voltage at the output with no input.
3. Adjust the gain to 10× for an unloaded output so that the nominal gain for an amplifier driving a 50Ω load will be 5× (or +14dB.)

Since the adjustments are interdependent, it is important that the adjustments be done in the prescribed order, and that all of the adjustments be done. For example, adjusting the high frequency compensation will affect the output offset.

## REQUIRED EQUIPMENT:

1. Pulse generator, splitter and attenuator to produce two  $\pm 100\text{mV}$  square waves with a rise time of less than 1nS. (ECL reference output from SR620 Time Interval Counter into unmatched tee driving two 50Ω cables with a 20dB attenuator on the one that goes to the SR240A.)
2. Digital voltmeter with 4-wire ohm measurement capability (Agilent 34401)
3. Digital oscilloscope with at least 300MHz bandwidth.

## HIGH FREQUENCY COMPENSATION

The SR240A uses an AD8009 current feedback amplifier in the output stage. The gain of the amplifier is controlled by the ratio of resistors in the feedback network and the bandwidth is controlled by the Thevenin equivalent source impedance of the feedback network. The ratio is fixed (by R115 & R116, R215 & R216, R315 & R316, R415 & R416) to provide a gain of 5× and the source impedance may be adjusted (by P102, P202, P302 and P402.)

The bandwidth is set to optimize the pulse response of the amplifier. This is done by applying a fast pulse at the input and adjusting P102 (or P202, P302 or P402 for channels 2, 3 & 4) so that the output rise time and overshoot most closely match the rise time and overshoot of the fast input pulse as observed on a 300MHz oscilloscope with 50  $\Omega$  input impedance.

Note that adjusting P102 will affect the offset for channel 1, as there is a large input bias current (150μA, max) to the inverting input of the AD8009. The offset will need to be adjusted after the HF compensation is adjusted.

1. Split the ECL reference output from SR620 with a coax tee. Take one cable from the tee to channel 1 of the oscilloscope (set to 50Ω input termination) and the other to the top channel of the SR240A via a 20dB coaxial attenuator.
2. Adjust P102 (Channel 1 HF compensation pot) to match the output rise time and overshoot to the input rise time and overshoot.
3. Repeat for the remaining three channels, adjusting the pulse response with P202, P302 or P402.

## OFFSET CALIBRATION

The output offset is affected by the HF compensation and so the offset should be nulled after the HF compensation is adjusted. The offset may also be affected by the amplifier gain adjustment if there is a large input offset voltage.

1. Leave the inputs unconnected.
2. Connect the output (without a 50Ω load) to the DVM on the mV dc range.
3. Adjust the offset pot (P101 for channel 1) to null the output voltage.



4. Verify that the output voltage shifts down by less than 2.5mV when a 50 $\Omega$  terminator is placed on the input. (The voltage shift will be  $10 \times [\text{the input bias current}] \times [\text{the change of input resistance} = 25\Omega]$  hence this measurement confirms that the input bias current is less than 10 $\mu$ A.)
5. Repeat the procedure to null the output of channels 2, 3 and 4 by adjusting P201, P301 and P401.

## GAIN CALIBRATION

The overall gain of the amplifier is 5 $\times$  when driving a 50 $\Omega$  load and 10 $\times$  when driving a high impedance load. The input source to the amplifier is typically a current source (such as the output from a photomultiplier) and so the magnitude of the input resistance is included in the gain calibration by calibrating the amplifier's transconductance. (Calibration is done with a current source as an input while measuring the voltage at the output.)

A DVM used in the 4-wire resistance mode is convenient for performing the calibration. Typically a DVM will measure small resistances by measuring the voltage across the resistor while passing a 1mA dc current through the resistor. We measure the gain of the amplifier by measuring the voltage at the output while applying test current to input. When the gain is properly adjusted, 1mA applied to the 50 $\Omega$  input generates 50mV at the input and 500mV at the (unterminated) output causing the DVM to indicate a "resistance" of 500 $\Omega$ . (To avoid auto ranging "confusion" by the DVM, a 453 $\Omega$  resistor is placed in series with the current source.)

Since the DVM uses a dc current as the test source, it is important that the amplifier offset be nulled prior to performing the dc gain adjustment.

1. Setup the DVM in the 4-wire resistance measurement mode.
2. Apply the current output to the amplifier input via a 453 $\Omega$  in-line resistor.
3. Apply the unterminated amplifier output to the DVM's 4-wire sense input.
4. Adjust the gain pot (P100 for channel 1, P200 for channel 2, P300 for channel 3, and P400 for channel 4) so that the DVM indicates a "resistance" of 500 $\Omega$ .
5. Verify that the offset was nulled by connecting the current source from the DVM to the input of the other channel and measuring a resistance of less than 1 $\Omega$ .
6. Repeat the gain adjustment for the second channel.

## CIRCUIT DESCRIPTION

(The four amplifier channels are identical. This description uses reference designators for the top channel.)

The input is terminated into 50 $\Omega$  by the parallel combination of R100 & R101. The input signal is coupled via a 47 $\Omega$  resistor to the high speed "clamp-amp", U100. U100 is configured as a non-inverting gain of 2 $\times$  amplifier. Pins 8 & 5 on U100 define input clamping thresholds of  $\pm 0.31$ Vdc. If the input signal exceeds these thresholds then U100 will use the clamping thresholds as inputs thereby limiting its output to  $\pm 0.62$ Vdc. This prevents the output of U100 from overdriving the next gain stage.

Input signals in excess of  $\pm 1.4$ Vdc are shunted to ground via the input protection diodes D100 & D101. Normally both the diodes in D100 are reversed biased and so they do not interfere with the signal. The diodes in D101 are forward biased by R103 & R104. When the input signal exceeds  $\pm 1.4$ Vdc (7 $\times$  the full scale input), one of the diodes in D100 will turn "on" thereby limiting the input to U100 to a safe level.

The gain of U100 can be adjusted by  $\pm 10\%$  by P100, which is calibrated at the factory to set the overall gain of the channel to 5 $\times$  when terminated into a 50 $\Omega$  load. The output of U100 is passed to the next gain stage via R112, a 47 $\Omega$  resistor.

The next stage has a fixed gain of 5 $\times$  with an adjustable offset and adjustable high frequency response. The gain of U101 is set by R115 & R116. The offset, adjusted by P101 and injected by R117, is nulled during calibration. The high frequency response of U101 is affected by the source impedance of its input signal and its

feedback network. Turning P102 clockwise decreases the source impedance of the feedback signal and increases the high frequency response of the gain stage. P102 is adjusted during calibration for an optimum pulse response providing a typical -3dB bandwidth of 350MHz.

The output from U101 is passed to the front panel output BNC via the parallel resistors R118 & R119, providing a 50  $\Omega$  output impedance. These resistors, in combination with the 50 $\Omega$  load resistor (provided by the user), attenuate the signal by 2 $\times$  so that the overall gain is 5 $\times$ .

Overloads are detected at the output of the second gain stage, U101. A positive overload is rectified by D102 and charges C107. A negative overload is rectified by D102 and discharges C106. One of the comparators in U102 will be driven low when the voltage on C106 or C107 exceeds  $\pm 1.7V$ . The driven comparator discharges C108 from +5V to -5V. C108 will be slowly recharged to +5V by R128, a 1M $\Omega$  resistor, thereby stretching the overload signal to about 10ms. One of the comparators in U504 (sheet 3 of the schematics) drives the front panel overload LED until the voltage on C108 recharges above ground. This overload detection will detect overloads as short as 3ns.

## POWER SUPPLIES

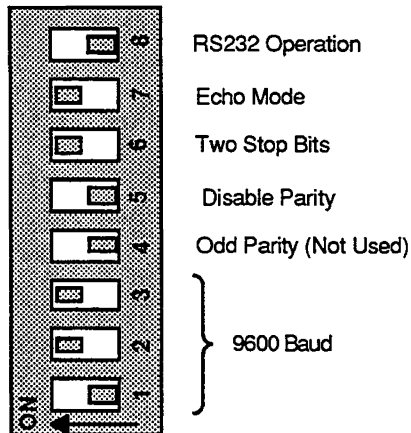
The  $\pm 12Vdc$  NIM power supplies are regulated to  $\pm 5Vdc$  by U502 and U503. The  $\pm 5Vdc$  power supplies are passively filtered by capacitors on the outputs of the regulators and by L/C filters for each amplifier channel. Careful power supply filtering is important to reduce channel crosstalk. The crosstalk from the output of channel 1 to the input of channel 2 is less than -60dB (1:1000 of the amplitude) and peaks around 300MHz. The crosstalk from the output of channel 2 to the input of channel 1 is less than -80dB (1:10,000 of the amplitude) and occurs in a broad band between 180MHz and 360MHz.



**EXAMPLE 1 - RS232 COMPUTER TERMINAL**

This example will allow you to communicate with the SR245 from a standard RS232 computer terminal.

1. Configure an ASCII terminal for 9600 baud, two stop bits, no parity bits, and 8 data bits.
2. Set the SR245 configuration switch as follows:



3. Place the 16 pin header in the socket marked 'DCE' (the lower socket of two, located near the RS232 connector on the inside of the SR245.)

4. Turn the NIM bin off, then on, to reset the SR245. The copyright sign-on message should appear on the screen along with the prompt 'OK->'.

5. Set voltages at the outputs and check them with a voltmeter as follows:

```

OK-> I0
OK-> S1=8
OK-> S2=7
OK-> S3=6
OK-> S4=5
OK-> S5=4
OK-> S6=3
OK-> S7=2
OK-> S8=1
OK-> ?1;?2;?3;?4;?5;?6;?7;?8
8.000
7.000
6.000
5.000
4.000
3.000
2.000
1.000
OK-> W0;?1;?2;?3;?4;?5;?6;?7;?8

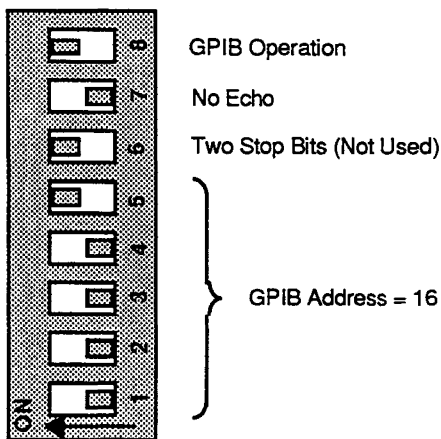
```

**EXAMPLE 2 - HP85 VIA GPIB (HPIB, IEEE-488)**

This program provides an example of an HP85 program using the HPIB interface which could be used to control a Boxcar Averager gate delay and retrieve and print the integrated outputs. The program self-triggers 100 times, provides an output ramp on port 8 from 1 to 5.5 volts (delay control voltage), and measures the the voltage at port one for each trigger (Boxcar Output.) The following hardware connections and settings must be made.

**Connection:**

ports B1 to B2	provide trigger (connect to Boxcar trig. also if desired)
port 8 to voltmeter	view voltage ramp (connect to Boxcar delay if desired)
port 1 to a voltage	measure output (connect to Boxcar last sample if desired)

**Configuration Switch:****Program:**

```

100 OUTPUT 716 ; "MR"
110 OUTPUT 716; "I4; MS; A18,1; T1; ET; W0"
130 OUTPUT 716; "S8=1"
135 OUTPUT 716; "SC1,8:100"
136 FOR I = 1 TO 100
137 OUTPUT 716; "PB2"
138 NEXT I
140 FOR I = 1 TO 100
150 OUTPUT 716; "N; N"
170 ENTER 716; A, D
180 PRINT A, D
270 NEXT I
400 END

```

**Note:**

When using the SR245 and the GPIB with certain computers, notably the HP 98XX series, a few precautions are necessary when sending the SR245 several commands on a single line. With these computers the following piece of BASIC code will not work:

```

10 OUTPUT 716; "?1; ?2"
20 ENTER 716; A, B

```

(assuming the SR245 address is 716)

This is because of a conflict in the terminating sequence expected by the computer and the one sent by the SR245. The SR245 provides (normally) a CR LF at the end of each answer it sends. The computers in question expect a CR separating each value on a CR LF at the end of a complete line. The problem can be easily solved by using the following alternate piece of code:

```

10 OUTPUT 716; "?1; ?2"
20 ENTER 716; A
30 ENTER 716; B

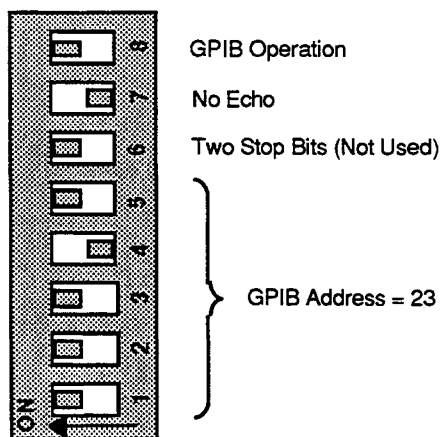
```

Note that this is not necessary on all computers, and is only an issue when using the GPIB. If any doubt exists, try both methods and see which one works.

**EXAMPLE 3 - IBM PC VIA GPIB (INTERPRETED BASIC)**

This program requires the Capital Equipment Corporation GPIB card which is a short card for the IBM PC or XT and has firmware in ROM to interface high level languages to the GPIB. In this program, the CEC card's ROM starts at OC0000H, the system controller's address is 21 and the SR245 has been assigned as GPIB address 23.

The configuration switch on the SR245 should be set as follows:



Calls in Microsoft's BASIC for the PC are done to memory locations specified by the name of the subroutine. The address is relative to the segment address specified by the DEF SEG statement preceding CALL.

To monitor the GPIB activity with an RS232 terminal, switch 7 should be set to ON, the SR245 configured as a DCE, and the ASCII terminal attached to the appropriate pin of the RS232. The terminal should be set for 9600 Baud, 8 data bits, 2 stop bits, and no parity.

Program:

```

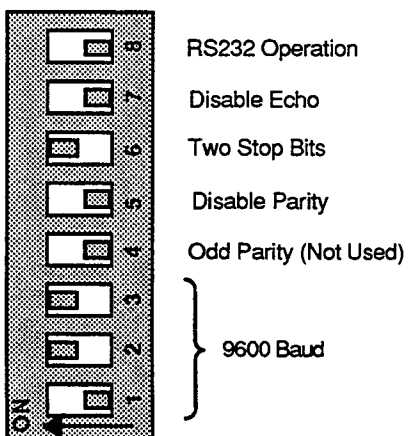
10 'GPIB TEST ROUTINE
20 'SENDS ?1 CONTINUALLY AND PRINTS RESPONSE
30 '
40 CLS
50 DEF SEG =&HC000 'ADDRESS OF CONTROLLER CARD
60 S$=SPACE$(80) 'USED TO ERASE INPUT LINE
70 INIT=0: TRANSMIT=3: RECV=6: ADDR%=21: SYS.CONT%=0
80 CALL INIT(ADDR%, SYS.CONT%)
90 A$="IFC MTA LISTEN 23 DATA '?' 13"
100 B$="UNL MLA TALK 23"
110 ANS$=SPACE$(10)
120 CALL TRANSMIT(A$, STATUS%)
130 IF STATUS%<>0 GOTO 200
140 CALL TRANSMIT(B$, STATUS%)
150 IF STATUS%<>0 GOTO 200
160 CALL RECV(ANS$, LENGTH%, STATUS%)
170 IF STATUS%<>0 GOTO 200
180 PRINT USING "##.###"; VAL(ANS$)
190 GOTO 120
200 PRINT "STATUS CODE ="; STATUS%
210 STOP
220 END

```

**EXAMPLE 4 - IBM PC VIA RS232 (BASIC)**

In this example, the IBM PC's "ASYNC" port (known as COM1: or AUX: to DOS users) will be used to communicate with the SR245. Only two wires between the IBM PC ASYNC port and the SR245 are required (pins #2 and #3 of RS232), but pins # 5,6,8,and 20 should be connected together on the connector at the IBM end.

Set the switches of the SR245 as follows:



After resetting the SR245 (toggle the Bin power switch), run the program. The eight values displayed on the screen are values read at the eight inputs of the SR245. Apply voltages at the 8 inputs to test for yourself. The values will be updated at about 1 Hz (Interpreted BASIC is slow).

Program:

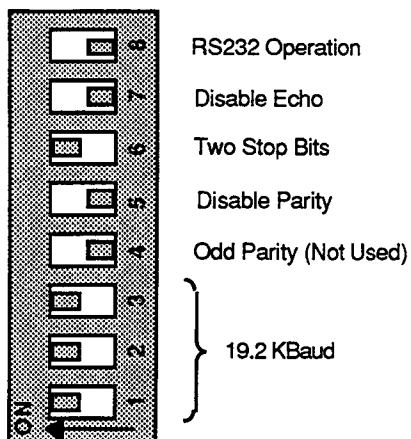
```

10 REM    Connect the Async port of the IBM to the SR245. You only
20 REM    need to connect pins 2 and 3 in this sample program.
30 REM
40 CLS
50 OPEN "COM1:9600,N,8,2,CS,DS,CD" AS #1
60 PRINT #1, "      "
70 PRINT #1, "MR; l8; W25"
80 LOCATE 1,1
90 FOR I = 1 TO 8
100 PRINT #1, USING "?#"; I
110 PRINT #1,
120 INPUT #1, V
130 PRINT USING "##.###";V
140 NEXT I
150 PRINT "loop count=", J
160 J = J + 1
170 GOTO 80

```

**EXAMPLE 5 - IBM PC VIA RS232 (FORTRAN)**

This program makes use of assembly language drivers to communicate with the SR245 via RS232. The SR245's internal 16 pin header should be in the socket marked DCE, and the configuration switch should be set as follows.



The program sets the first four ports of the SR245 as inputs. It then reads those four ports continuously, displaying its readings to a scrolling screen. The program may be paused and resumed by typing control S, and program execution is halted by typing control C. `ftst.for` is written in Microsoft FORTRAN v3.3. It makes calls to procedures in `rs232.asm` which is written in Microsoft MACRO Assembler v1.25.

To compile `ftst.for`:            `for1 ftst;`  
   `pas2`

To assemble `rs232.asm`:        `masm rs232;`

To link:                            `link ftst rs232/NOD;`

To execute:                        `ftst`

```

c      ftst.for
c
c      A FORTRAN program that uses assembly language drivers
c      to communicate with the SR245 via RS232.
c
c      S. Lindgren    12/11/86
c
c
c      program ftst
c
c      character      io*40
c      real           v(4)
c
c      Initialize computer's RS232 port COM1:
c      call bgn232
c
c      Initialize the SR245
c      call snd232 ('W0;l4$')
c
c      The '$' is required by snd232 to mark the end of the string.
c      It is not sent to the SR245.
c
100    do 200 i=1,4
c
c      Request an input voltage
c      write (io, 1000) i
1000  format (BN, '?', l1, '$')
c      call snd232 (io)
c
c      Receive an input voltage

```



```

        call rcv232 (io)
        read (io, 1100) v(i)
1100    format (BN, F8.3)

200     continue

c       Write the four voltages to the screen.
        write (*, 1200) v(1), v(2), v(3), v(4)
1200    format (2X, F8.3, 2X, F8.3, 2X, F8.3, 2X, F8.3)

        goto 100

        end

```

---

```

;rs232.asm

```

```

;rs232 interface procedures: bgn232, snd232, rcv232

```

```

                page    60,132

data            segment      public  'data'

data            ends

dgroup          group  data
code             segment      'code'
                assume cs:code,ds:dgroup,ss:dgroup

public bgn232
bgn232          proc      far

status          equ    3fdh          ;UART status port address
modcon          equ    3fch          ;modem status reg
rxdata          equ    3f8h          ;UART data port address
intreg          equ    3f9h          ;UART interrupt register
lnctl           equ    3fbh          ;UART line control register
divreg          equ    3f9h          ;UART divisor register

keybrd          equ    16h           ;Int for rom bios call for keyboard
rs232           equ    14h           ;Int for rom bios service of rs232
cr              equ    0dh           ;carriage return
lf              equ    0ah           ;line feed

                push    bp           ;save the frame pointer
                mov     bp,sp        ;get the pointer to the function code

```

```

;           Initialize the RS232 port.

init:      mov     ah,0           ;initialize request
           mov     dx,0           ;point to the first card
           mov     al,11100111b  ;9600 baud, no parity, 2 stop bits
           int     rs232         ;off to rom bios

;           now set 19.2 Kbaud operation

           mov     dx,lnc1l      ;point to line control register
           in      al,dx         ;get it
           mov     ah,al         ;save it
           or      al,10000000b  ;turn on divisor access bit
           out     dx,al

           mov     dx,divreg     ;point to msb of divisor
           sub     al,al         ;this is 0
           out     dx,al
           mov     al,6h         ;19.2 kbaud
           dec     dx           ;point to lsb of divisor
           out     dx,al

           mov     dx,lnc1l      ;point to line control reg
           mov     al,ah         ;restore divisor latch to 0
           out     dx,al

;           end of 19.2 set

           mov     dx,intreg     ;turn off UART interrupts
           sub     al,al
           out     dx,al
           mov     al,00000111b ;set clear to send
           mov     dx,modcon     ;modem control reg
           out     dx,al
           mov     dx,status     ;point to the status port
           in      al,dx         ;clear errors
           mov     dx,rxdata     ;point to data port
           in      al,dx         ;clear pending data

           pop     bp
           ret

bgn232     endp

public    snd232
snd232    proc    far

;           Send a string via the COM1: port. Stop sending when a '$' is
;           found in the string. Do not send the '$'.

send:     push    bp
           mov     bp,sp

```

```

        push    ds
        lds     si,dword ptr [bp+6]    ;point to the first character to go
        sub     cx,cx                  ;will flag end of string when <=>0
        cld

gtnxt:   lodsb                     ;get the character
        mov     ah,al                ;save it
        cmp     al','$'              ;test for end of string
        jnz     arnd                 ;jump if not at end of string

last:    mov     al,cr                ;substitute a CR
        mov     ah,al
        mov     cx,1                 ;flag done

arnd:    cmp     al,''               ;check for a superfluous blank
        jz      short gtnxt

xhold1:  mov     dx,status            ;get transmitter status
        in      al,dx                ;get status
        test    al,20h
        jz      xhold1              ;if not ready wait

        mov     dx,rxdata            ;output the character
        mov     al,ah
        out     dx,al

        jcxz    short gtnxt

        pop     ds
        pop     bp
        ret     04

snd232   endp

public   rcv232
rcv232   proc    far

        push    bp
        mov     bp,sp

        les     di,dword ptr [bp+6] ;point to the start of the string

;        get the character

        mov     cx,15                ;counter for blanks
        mov     bx,0ffffh            ;counter for timeout loop
        cld

statlp:  mov     dx,status            ;point to the status port
        dec     bx
        jz      timeout

```

```

        in      al,dx      ;get the status byte
        test   al,1        ;check for received data
        jz     statlp      ;wait for data

        mov     dx,rxdata   ;point to the data port
        in      al,dx       ;get the data byte

        stosb                ;place the character in the string
        dec     cx           ;decrement number of blanks to place

        cmp     al,0dh      ;was it a <cr>?
        jnz     statlp      ;go back for more characters

        dec     di
        mov     al,' '      ;clear remainder of buffer
rep     stosb                ;fill with spaces

timeout:  mov     sp,bp
        pop     bp
        ret     04

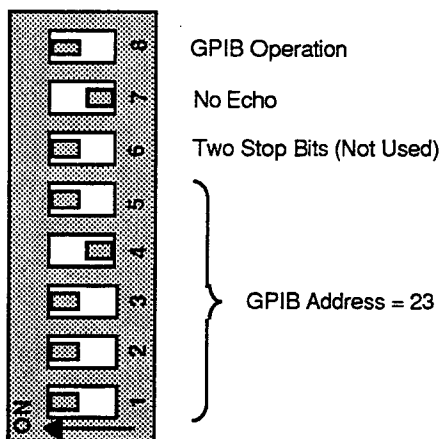
rcv232   endp

code     ends
        end
```

---

**EXAMPLE 6 - IBM PC VIA GPIB USING C**

This program is the same as the one in Example 5 except that it is written in C and communicates via GPIB. The SR245's configuration switch should be set as follows.



The program sets the first four ports of the SR245 as inputs. It then reads those four ports continuously, displaying its readings to a scrolling screen. The program may be paused and resumed by typing control S, and program execution is halted by typing control C. `ctst.c` is written in Microsoft C v3.0. It makes calls to procedures in GPIB-L which is included with the Capital Equipment Corp. GPIB card. Similar software is provided with other GPIB cards.

To compile `ctst.c`: `msc ctst/Ze/AL;`

To link: `link ctst GPIB-L;`

To execute: `ctst`

```
/* ***** ctst.c ***** */
```

```
/* C program that communicates with the SR245 via GPIB.
   The functions initialize(), transmit(), and receive()
   are defined in GPIB-L.
```

```
   S. Lindgren    12/15/86
```

```
*/
```

```
#include <ms-c488.h> /* provided with CEC gpib card */
```

```
#define sr245 23 /* gpib address */
```

```
int status, length;
```

```
main ()
```

```
{
    int i;
    float v[4];
    char cmd[20], *recv, *get_gpib (int);
```

```
    /* Initialize the computer's GPIB card and the SR245 */
    setup();
```

```

while (1)
{
    for (i=1 ; i<=4 ; i++)
    {
        /* Request an input voltage */
        sprintf (cmd, " '?%d' 13", i);
        tx_gpib (sr245, cmd);

        /* Receive an input voltage */
        recv = get_gpib (sr245);
        sscanf (recv, "%f", &v[i-1]);
    }

    /* Write the four voltages to the screen */
    printf ("%7.3f %7.3f %7.3f %7.3f\n", v[0], v[1], v[2], v[3]);
}

/* ***** */

setup ()
{
    int my_address=21, system_controller=0;

    initialize (&system_controller, &my_address);
    transmit (&status, "IFC UNT UNL DCL");
    wait(2);
    transmit (&status, "IFC UNT UNL MTA REN");
    wait(2);
    tx_gpib (sr245, " 'W0;l4' 13");
}

/* ***** */

tx_gpib (address,command)

int address;
char *command;
{
    char t_string[100];

    sprintf (t_string,"UNT MTA LISTEN %d DATA %s", address, command);
    transmit (&status, t_string);
    statcheck (address);
}

```

```

/* ***** */

char *get_gpib (address)

int address;
{
    char r_string[40], recv[80];

    sprintf (r_string, "UNL MLA TALK %d", address);
    transmit (&status, r_string);
    statcheck (address);

    strcpy (recv, " ");
    receive (&status, &length, recv);
    statcheck (address);
    return (recv);
}

/* ***** */

/* check the gpib status and exit if error */

statcheck (address)
int address;
{
    if (status != 0)
    {
        printf ("Error at device %d, status = %d\n", address, status);
        exit ();
    }
}

/* ***** */

wait (n) /* wait n seconds */
int n;
{
    int i,j,dum;
    for (j=n ; j>=1 ; j--)
    {
        for (i=0 ; i<=32000 ; i++)
            dum = 10*10;
    }
}

```

**COMPONENT PARTS LIST****Model SR200 Parts List**

<u>Ref.</u>	<u>SRS Part#</u>	<u>Value</u>	<u>Description</u>
C 1	5-00074-515	.015U	Capacitor, Mylar/Poly, 50V, 10%, Rad
C 2	5-00073-513	4.7U	Capacitor, Mylar/Poly, 50V, 5%, Rad
C 3	5-00028-507	100P	Capacitor, Ceramic Disc, 250V, 10%, Y5P
C 4	5-00028-507	100P	Capacitor, Ceramic Disc, 250V, 10%, Y5P
C 5	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C 6	5-00028-507	100P	Capacitor, Ceramic Disc, 250V, 10%, Y5P
C 7	5-00028-507	100P	Capacitor, Ceramic Disc, 250V, 10%, Y5P
C 8	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C 9	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C 10	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C 11	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C 12	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C 13	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 14	5-00099-517	1U	Capacitor, Tantalum, 35V, 20%, Rad
C 15	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C 16	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C 17	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C 18	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C 19	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C 20	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
D 1	3-00004-301	1N4148	Diode
D 2	3-00006-301	1N746A	Diode
D 3	3-00010-303	GREEN	LED, T1 Package
D 4	3-00009-303	YELLOW	LED, T1 Package
D 5	3-00011-303	RED	LED, T1 Package
P 1	4-00019-443	20K	Pot, 10-Turn Panel
P 2	4-00019-443	20K	Pot, 10-Turn Panel
P 3	4-00007-440	20K	Trim Pot, Single Turn, In-Line Leads
PC1	7-00028-701	SR200	Printed Circuit Board
Q 1	3-00021-325	2N3904	Transistor, TO-92 Package
Q 2	3-00021-325	2N3904	Transistor, TO-92 Package
Q 3	3-00021-325	2N3904	Transistor, TO-92 Package
Q 4	3-00021-325	2N3904	Transistor, TO-92 Package
R 1	4-00074-401	33K	Resistor, Carbon Film, 1/4W, 5%
R 2	4-00074-401	33K	Resistor, Carbon Film, 1/4W, 5%
R 3	4-00021-401	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 4	4-00021-401	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 5	4-00070-401	30K	Resistor, Carbon Film, 1/4W, 5%
R 6	4-00106-401	91K	Resistor, Carbon Film, 1/4W, 5%
R 7	4-00069-401	300K	Resistor, Carbon Film, 1/4W, 5%
R 8	4-00105-401	910K	Resistor, Carbon Film, 1/4W, 5%
R 9	4-00064-401	3.0M	Resistor, Carbon Film, 1/4W, 5%
R 10	4-00106-401	91K	Resistor, Carbon Film, 1/4W, 5%
R 11	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 12	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%



<u>Ref.</u>	<u>SRS Part#</u>	<u>Value</u>	<u>Description</u>
R 13	4-00059-401	22K	Resistor, Carbon Film, 1/4W, 5%
R 14	4-00059-401	22K	Resistor, Carbon Film, 1/4W, 5%
R 15	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 16	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 17	4-00059-401	22K	Resistor, Carbon Film, 1/4W, 5%
R 18	4-00059-401	22K	Resistor, Carbon Film, 1/4W, 5%
R 19	4-00079-401	4.7K	Resistor, Carbon Film, 1/4W, 5%
R 20	4-00079-401	4.7K	Resistor, Carbon Film, 1/4W, 5%
R 21	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 22	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 23	4-00048-401	2.2K	Resistor, Carbon Film, 1/4W, 5%
R 24	4-00048-401	2.2K	Resistor, Carbon Film, 1/4W, 5%
R 25	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 26	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 27	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 28	4-00059-401	22K	Resistor, Carbon Film, 1/4W, 5%
R 29	4-00059-401	22K	Resistor, Carbon Film, 1/4W, 5%
R 30	4-00092-401	56K	Resistor, Carbon Film, 1/4W, 5%
R 31	4-00138-407	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 32	4-00138-407	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 33	4-00138-407	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 34	4-00138-407	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 35	4-00048-401	2.2K	Resistor, Carbon Film, 1/4W, 5%
R 36	4-00021-401	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 37	4-00022-401	1.0M	Resistor, Carbon Film, 1/4W, 5%
R 38	4-00081-401	470	Resistor, Carbon Film, 1/4W, 5%
R 39	4-00083-401	47K	Resistor, Carbon Film, 1/4W, 5%
R 40	4-00081-401	470	Resistor, Carbon Film, 1/4W, 5%
R 41	4-00083-401	47K	Resistor, Carbon Film, 1/4W, 5%
R 42	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 43	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 44	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 45	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 46	4-00043-401	180	Resistor, Carbon Film, 1/4W, 5%
R 47	4-00043-401	180	Resistor, Carbon Film, 1/4W, 5%
R 49	4-00109-402	220	Resistor, Carbon Comp, 1/2W, 5%
R 50	4-00043-401	180	Resistor, Carbon Film, 1/4W, 5%
SW1	2-00007-214	SPDT	Switch, Miniature Bat Toggle
SW2	2-00007-214	SPDT	Switch, Miniature Bat Toggle
SW3	2-00019-210	2P12T	Switch, Rotary, PCB Mounted
U 1	3-00087-340	LF347	Integrated Circuit (Thru-hole Pkg)
U 2	3-00098-340	LM324	Integrated Circuit (Thru-hole Pkg)
U 3	3-00098-340	LM324	Integrated Circuit (Thru-hole Pkg)
U 4	3-00067-340	CD4013	Integrated Circuit (Thru-hole Pkg)
U 5	3-00067-340	CD4013	Integrated Circuit (Thru-hole Pkg)
U 6	3-00070-340	CD4025	Integrated Circuit (Thru-hole Pkg)
U 7	3-00071-340	CD4030	Integrated Circuit (Thru-hole Pkg)
U 8	3-00069-340	CD4019	Integrated Circuit (Thru-hole Pkg)
U 9	3-00073-340	CD4052	Integrated Circuit (Thru-hole Pkg)

<b>Ref.</b>	<b>SRS Part#</b>	<b>Value</b>	<b>Description</b>
U 10	3-00112-329	7805	Voltage Reg., TO-220 (TAB) Package
U 11	3-00114-329	7815	Voltage Reg., TO-220 (TAB) Package
U 12	3-00120-329	7915	Voltage Reg., TO-220 (TAB) Package
Z 0	0-00002-008	2607	Dial
Z 0	0-00022-004	KLN500B1/8	Knobs
Z 0	0-00030-060	NIM FP	Screw, Misc
Z 0	0-00031-006	200833-2	NIM (Nuclear Instrumentation Module)
Z 0	0-00032-006	202394-2	NIM (Nuclear Instrumentation Module)
Z 0	0-00034-006	202514-1	NIM (Nuclear Instrumentation Module)
Z 0	0-00036-006	203964-5	NIM (Nuclear Instrumentation Module)
Z 0	0-00037-006	204186-5	NIM (Nuclear Instrumentation Module)
Z 0	0-00040-006	66103-4	NIM (Nuclear Instrumentation Module)
Z 0	0-00043-011	4-40 KEP	Nut, Kep
Z 0	0-00061-061	4-40X3/8B	Screw, Binding Head, Slotted
Z 0	0-00089-033	4"	Tie
Z 0	0-00108-054	1" #26	Wire #26 UL1061
Z 0	0-00117-053	12" #24	Wire #24 UL1007 Strip 1/4x1/4 Tin
Z 0	0-00132-053	6-1/2" #24	Wire #24 UL1007 Strip 1/4x1/4 Tin
Z 0	0-00133-052	7-1/2" #22	Wire #22 UL1007
Z 0	0-00134-053	7-1/4" #24	Wire #24 UL1007 Strip 1/4x1/4 Tin
Z 0	0-00136-053	8-1/2" #24	Wire #24 UL1007 Strip 1/4x1/4 Tin
Z 0	0-00140-009	SHEET	Mylar Sheet
Z 0	0-00187-021	4-40X1/4PP	Screw, Panhead Phillips
Z 0	0-00229-031	6-32 NIM FP	Standoff
Z 0	0-00230-061	4-40X1/4B	Screw, Binding Head, Slotted
Z 0	1-00003-120	BNC	Connector, BNC
Z 0	7-00012-710	SR200	Front Panel
Z 0	7-00041-711	SR200-7	Rear Panel
Z 0	7-00078-714	SR200-13	Extrusion
Z 0	7-00087-712	SR200-8	Side Panel
Z 0	7-00088-720	SR200-12	Fabricated Part
Z 0	7-00091-720	25-001	Fabricated Part
Z 0	7-00094-714	26-001	Extrusion
Z 0	9-00267-917	GENERIC	Product Labels

**Model SR240A Parts List**

<b><u>Ref.</u></b>	<b><u>SRS Part#</u></b>	<b><u>Value</u></b>	<b><u>Description</u></b>
C 100	5-00299-568	.1U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 101	5-00299-568	.1U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 102	5-00299-568	.1U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 103	5-00299-568	.1U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 104	5-00299-568	.1U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 105	5-00299-568	.1U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 106	5-00375-552	100P	Capacitor, Chip (SMT1206), 50V, 5%, NPO
C 107	5-00375-552	100P	Capacitor, Chip (SMT1206), 50V, 5%, NPO
C 108	5-00298-568	.01U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 110	5-00472-569	4.7U/T35	Cap, Tantalum, SMT (all case sizes)
C 111	5-00472-569	4.7U/T35	Cap, Tantalum, SMT (all case sizes)
C 200	5-00299-568	.1U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 201	5-00299-568	.1U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 202	5-00299-568	.1U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 203	5-00299-568	.1U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 204	5-00299-568	.1U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 205	5-00299-568	.1U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 206	5-00375-552	100P	Capacitor, Chip (SMT1206), 50V, 5%, NPO
C 207	5-00375-552	100P	Capacitor, Chip (SMT1206), 50V, 5%, NPO
C 208	5-00298-568	.01U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 210	5-00472-569	4.7U/T35	Cap, Tantalum, SMT (all case sizes)
C 211	5-00472-569	4.7U/T35	Cap, Tantalum, SMT (all case sizes)
C 300	5-00299-568	.1U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 301	5-00299-568	.1U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 302	5-00299-568	.1U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 303	5-00299-568	.1U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 304	5-00299-568	.1U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 305	5-00299-568	.1U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 306	5-00375-552	100P	Capacitor, Chip (SMT1206), 50V, 5%, NPO
C 307	5-00375-552	100P	Capacitor, Chip (SMT1206), 50V, 5%, NPO
C 308	5-00298-568	.01U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 310	5-00472-569	4.7U/T35	Cap, Tantalum, SMT (all case sizes)
C 311	5-00472-569	4.7U/T35	Cap, Tantalum, SMT (all case sizes)
C 400	5-00299-568	.1U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 401	5-00299-568	.1U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 402	5-00299-568	.1U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 403	5-00299-568	.1U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 404	5-00299-568	.1U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 405	5-00299-568	.1U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 406	5-00375-552	100P	Capacitor, Chip (SMT1206), 50V, 5%, NPO
C 407	5-00375-552	100P	Capacitor, Chip (SMT1206), 50V, 5%, NPO
C 408	5-00298-568	.01U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 410	5-00472-569	4.7U/T35	Cap, Tantalum, SMT (all case sizes)
C 411	5-00472-569	4.7U/T35	Cap, Tantalum, SMT (all case sizes)
C 502	5-00472-569	4.7U/T35	Cap, Tantalum, SMT (all case sizes)
C 504	5-00472-569	4.7U/T35	Cap, Tantalum, SMT (all case sizes)
C 505	5-00299-568	.1U	Cap, Ceramic 50V SMT (1206) +/-10% X7R

<u>Ref.</u>	<u>SRS Part#</u>	<u>Value</u>	<u>Description</u>
C 506	5-00299-568	.1U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 507	5-00299-568	.1U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 508	5-00299-568	.1U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 509	5-00299-568	.1U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 510	5-00299-568	.1U	Cap, Ceramic 50V SMT (1206) +/-10% X7R
C 511	5-00472-569	4.7U/T35	Cap, Tantalum, SMT (all case sizes)
C 512	5-00472-569	4.7U/T35	Cap, Tantalum, SMT (all case sizes)
D 100	3-00896-301	BAV99	Diode
D 101	3-00896-301	BAV99	Diode
D 102	3-00896-301	BAV99	Diode
D 200	3-00896-301	BAV99	Diode
D 201	3-00896-301	BAV99	Diode
D 202	3-00896-301	BAV99	Diode
D 300	3-00896-301	BAV99	Diode
D 301	3-00896-301	BAV99	Diode
D 302	3-00896-301	BAV99	Diode
D 400	3-00896-301	BAV99	Diode
D 401	3-00896-301	BAV99	Diode
D 402	3-00896-301	BAV99	Diode
D 601	3-00011-303	RED	LED, T1 Package
D 602	3-00011-303	RED	LED, T1 Package
D 603	3-00011-303	RED	LED, T1 Package
D 604	3-00011-303	RED	LED, T1 Package
J 100	1-00003-120	BNC	Connector, BNC
J 101	1-00003-120	BNC	Connector, BNC
J 200	1-00003-120	BNC	Connector, BNC
J 201	1-00003-120	BNC	Connector, BNC
J 300	1-00003-120	BNC	Connector, BNC
J 301	1-00003-120	BNC	Connector, BNC
J 400	1-00003-120	BNC	Connector, BNC
J 401	1-00003-120	BNC	Connector, BNC
J 506	1-01043-171	5POS .100 JMPR	Cable Assembly, Ribbon
L 100	6-00236-631	FR47	Ferrite bead, SMT
L 101	6-00236-631	FR47	Ferrite bead, SMT
L 200	6-00236-631	FR47	Ferrite bead, SMT
L 201	6-00236-631	FR47	Ferrite bead, SMT
L 300	6-00236-631	FR47	Ferrite bead, SMT
L 301	6-00236-631	FR47	Ferrite bead, SMT
L 400	6-00236-631	FR47	Ferrite bead, SMT
L 401	6-00236-631	FR47	Ferrite bead, SMT
P 100	4-01614-441	10	Pot, Multi-Turn Trim, 3/8" Square Top Ad
P 101	4-00011-441	10K	Pot, Multi-Turn Trim, 3/8" Square Top Ad
P 102	4-00353-441	100	Pot, Multi-Turn Trim, 3/8" Square Top Ad
P 200	4-01614-441	10	Pot, Multi-Turn Trim, 3/8" Square Top Ad
P 201	4-00011-441	10K	Pot, Multi-Turn Trim, 3/8" Square Top Ad
P 202	4-00353-441	100	Pot, Multi-Turn Trim, 3/8" Square Top Ad
P 300	4-01614-441	10	Pot, Multi-Turn Trim, 3/8" Square Top Ad
P 301	4-00011-441	10K	Pot, Multi-Turn Trim, 3/8" Square Top Ad
P 302	4-00353-441	100	Pot, Multi-Turn Trim, 3/8" Square Top Ad

<u>Ref.</u>	<u>SRS Part#</u>	<u>Value</u>	<u>Description</u>
P 400	4-01614-441	10	Pot, Multi-Turn Trim, 3/8" Square Top Ad
P 401	4-00011-441	10K	Pot, Multi-Turn Trim, 3/8" Square Top Ad
P 402	4-00353-441	100	Pot, Multi-Turn Trim, 3/8" Square Top Ad
PC1	7-01479-701	SR445A/240A	Printed Circuit Board
R 100	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 101	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 102	4-01447-461	47	Thick Film, 5%, 200 ppm, Chip Resistor
R 103	4-01503-461	10K	Thick Film, 5%, 200 ppm, Chip Resistor
R 104	4-01503-461	10K	Thick Film, 5%, 200 ppm, Chip Resistor
R 105	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 106	4-01134-462	1.50K	Thin Film, 1%, 50 ppm, MELF Resistor
R 107	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 108	4-01134-462	1.50K	Thin Film, 1%, 50 ppm, MELF Resistor
R 109	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 110	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 112	4-01447-461	47	Thick Film, 5%, 200 ppm, Chip Resistor
R 115	4-01050-462	200	Thin Film, 1%, 50 ppm, MELF Resistor
R 116	4-00992-462	49.9	Thin Film, 1%, 50 ppm, MELF Resistor
R 117	4-01242-462	20.0K	Thin Film, 1%, 50 ppm, MELF Resistor
R 118	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 119	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 120	4-01527-461	100K	Thick Film, 5%, 200 ppm, Chip Resistor
R 121	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 122	4-01134-462	1.50K	Thin Film, 1%, 50 ppm, MELF Resistor
R 123	4-01134-462	1.50K	Thin Film, 1%, 50 ppm, MELF Resistor
R 124	4-01527-461	100K	Thick Film, 5%, 200 ppm, Chip Resistor
R 125	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 126	4-01163-462	3.01K	Thin Film, 1%, 50 ppm, MELF Resistor
R 127	4-01163-462	3.01K	Thin Film, 1%, 50 ppm, MELF Resistor
R 128	4-01551-461	1.0M	Thick Film, 5%, 200 ppm, Chip Resistor
R 200	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 201	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 202	4-01447-461	47	Thick Film, 5%, 200 ppm, Chip Resistor
R 203	4-01503-461	10K	Thick Film, 5%, 200 ppm, Chip Resistor
R 204	4-01503-461	10K	Thick Film, 5%, 200 ppm, Chip Resistor
R 205	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 206	4-01134-462	1.50K	Thin Film, 1%, 50 ppm, MELF Resistor
R 207	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 208	4-01134-462	1.50K	Thin Film, 1%, 50 ppm, MELF Resistor
R 209	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 210	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 212	4-01447-461	47	Thick Film, 5%, 200 ppm, Chip Resistor
R 215	4-01050-462	200	Thin Film, 1%, 50 ppm, MELF Resistor
R 216	4-00992-462	49.9	Thin Film, 1%, 50 ppm, MELF Resistor
R 217	4-01242-462	20.0K	Thin Film, 1%, 50 ppm, MELF Resistor
R 218	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 219	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 220	4-01527-461	100K	Thick Film, 5%, 200 ppm, Chip Resistor
R 221	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor

<u>Ref.</u>	<u>SRS Part#</u>	<u>Value</u>	<u>Description</u>
R 222	4-01134-462	1.50K	Thin Film, 1%, 50 ppm, MELF Resistor
R 223	4-01134-462	1.50K	Thin Film, 1%, 50 ppm, MELF Resistor
R 224	4-01527-461	100K	Thick Film, 5%, 200 ppm, Chip Resistor
R 225	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 226	4-01163-462	3.01K	Thin Film, 1%, 50 ppm, MELF Resistor
R 227	4-01163-462	3.01K	Thin Film, 1%, 50 ppm, MELF Resistor
R 228	4-01551-461	1.0M	Thick Film, 5%, 200 ppm, Chip Resistor
R 300	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 301	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 302	4-01447-461	47	Thick Film, 5%, 200 ppm, Chip Resistor
R 303	4-01503-461	10K	Thick Film, 5%, 200 ppm, Chip Resistor
R 304	4-01503-461	10K	Thick Film, 5%, 200 ppm, Chip Resistor
R 305	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 306	4-01134-462	1.50K	Thin Film, 1%, 50 ppm, MELF Resistor
R 307	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 308	4-01134-462	1.50K	Thin Film, 1%, 50 ppm, MELF Resistor
R 309	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 310	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 312	4-01447-461	47	Thick Film, 5%, 200 ppm, Chip Resistor
R 315	4-01050-462	200	Thin Film, 1%, 50 ppm, MELF Resistor
R 316	4-00992-462	49.9	Thin Film, 1%, 50 ppm, MELF Resistor
R 317	4-01242-462	20.0K	Thin Film, 1%, 50 ppm, MELF Resistor
R 318	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 319	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 320	4-01527-461	100K	Thick Film, 5%, 200 ppm, Chip Resistor
R 321	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 322	4-01134-462	1.50K	Thin Film, 1%, 50 ppm, MELF Resistor
R 323	4-01134-462	1.50K	Thin Film, 1%, 50 ppm, MELF Resistor
R 324	4-01527-461	100K	Thick Film, 5%, 200 ppm, Chip Resistor
R 325	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 326	4-01163-462	3.01K	Thin Film, 1%, 50 ppm, MELF Resistor
R 327	4-01163-462	3.01K	Thin Film, 1%, 50 ppm, MELF Resistor
R 328	4-01551-461	1.0M	Thick Film, 5%, 200 ppm, Chip Resistor
R 400	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 401	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 402	4-01447-461	47	Thick Film, 5%, 200 ppm, Chip Resistor
R 403	4-01503-461	10K	Thick Film, 5%, 200 ppm, Chip Resistor
R 404	4-01503-461	10K	Thick Film, 5%, 200 ppm, Chip Resistor
R 405	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 406	4-01134-462	1.50K	Thin Film, 1%, 50 ppm, MELF Resistor
R 407	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 408	4-01134-462	1.50K	Thin Film, 1%, 50 ppm, MELF Resistor
R 409	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 410	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 412	4-01447-461	47	Thick Film, 5%, 200 ppm, Chip Resistor
R 415	4-01050-462	200	Thin Film, 1%, 50 ppm, MELF Resistor
R 416	4-00992-462	49.9	Thin Film, 1%, 50 ppm, MELF Resistor
R 417	4-01242-462	20.0K	Thin Film, 1%, 50 ppm, MELF Resistor
R 418	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor

<u>Ref.</u>	<u>SRS Part#</u>	<u>Value</u>	<u>Description</u>
R 419	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 420	4-01527-461	100K	Thick Film, 5%, 200 ppm, Chip Resistor
R 421	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 422	4-01134-462	1.50K	Thin Film, 1%, 50 ppm, MELF Resistor
R 423	4-01134-462	1.50K	Thin Film, 1%, 50 ppm, MELF Resistor
R 424	4-01527-461	100K	Thick Film, 5%, 200 ppm, Chip Resistor
R 425	4-01021-462	100	Thin Film, 1%, 50 ppm, MELF Resistor
R 426	4-01163-462	3.01K	Thin Film, 1%, 50 ppm, MELF Resistor
R 427	4-01163-462	3.01K	Thin Film, 1%, 50 ppm, MELF Resistor
R 428	4-01551-461	1.0M	Thick Film, 5%, 200 ppm, Chip Resistor
R 505	4-01479-461	1.0K	Thick Film, 5%, 200 ppm, Chip Resistor
R 506	4-01479-461	1.0K	Thick Film, 5%, 200 ppm, Chip Resistor
R 507	4-01479-461	1.0K	Thick Film, 5%, 200 ppm, Chip Resistor
R 508	4-01479-461	1.0K	Thick Film, 5%, 200 ppm, Chip Resistor
R 509	4-01479-461	1.0K	Thick Film, 5%, 200 ppm, Chip Resistor
U 100	3-00897-360	AD8037	Integrated Circuit (Surface Mount Pkg)
U 101	3-00898-360	AD8009	Integrated Circuit (Surface Mount Pkg)
U 102	3-00728-360	LM393	Integrated Circuit (Surface Mount Pkg)
U 200	3-00897-360	AD8037	Integrated Circuit (Surface Mount Pkg)
U 201	3-00898-360	AD8009	Integrated Circuit (Surface Mount Pkg)
U 202	3-00728-360	LM393	Integrated Circuit (Surface Mount Pkg)
U 300	3-00897-360	AD8037	Integrated Circuit (Surface Mount Pkg)
U 301	3-00898-360	AD8009	Integrated Circuit (Surface Mount Pkg)
U 302	3-00728-360	LM393	Integrated Circuit (Surface Mount Pkg)
U 400	3-00897-360	AD8037	Integrated Circuit (Surface Mount Pkg)
U 401	3-00898-360	AD8009	Integrated Circuit (Surface Mount Pkg)
U 402	3-00728-360	LM393	Integrated Circuit (Surface Mount Pkg)
U 502	3-00112-329	7805	Voltage Reg., TO-220 (TAB) Package
U 503	3-00119-329	7905	Voltage Reg., TO-220 (TAB) Package
U 504	3-00728-360	LM393	Integrated Circuit (Surface Mount Pkg)
U 505	3-00728-360	LM393	Integrated Circuit (Surface Mount Pkg)
Z 0	0-00030-060	NIM FP	Screw, Misc
Z 0	0-00031-006	200833-2	NIM (Nuclear Instrumentation Module)
Z 0	0-00032-006	202394-2	NIM (Nuclear Instrumentation Module)
Z 0	0-00034-006	202514-1	NIM (Nuclear Instrumentation Module)
Z 0	0-00036-006	203964-5	NIM (Nuclear Instrumentation Module)
Z 0	0-00037-006	204186-5	NIM (Nuclear Instrumentation Module)
Z 0	0-00040-006	66103-4	NIM (Nuclear Instrumentation Module)
Z 0	0-00043-011	4-40 KEP	Nut, Kep
Z 0	0-00061-061	4-40X3/8B	Screw, Binding Head, Slotted
Z 0	0-00187-021	4-40X1/4PP	Screw, Panhead Phillips
Z 0	0-00230-061	4-40X1/4B	Screw, Binding Head, Slotted
Z 0	0-00259-021	4-40X1/2"PP	Screw, Panhead Phillips
Z 0	0-00438-021	4-40X5/16PP	Screw, Panhead Phillips
Z 0	7-00084-711	22-001	Rear Panel
Z 0	7-00087-712	SR200-8	Side Panel
Z 0	7-00088-720	SR200-12	Fabricated Part
Z 0	7-00091-720	25-001	Fabricated Part
Z 0	7-00094-714	26-001	Extrusion

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<u>Ref.</u>	<u>SRS Part#</u>	<u>Value</u>	<u>Description</u>
Z 0	7-00380-721	SR445A/SR240A	Machined Part
Z 0	7-01505-720	SR240A-F/P	Fabricated Part
Z 0	9-00267-917	GENERIC	Product Labels



**Model SR235 Parts List**

<b>Ref.</b>	<b>SRS Part#</b>	<b>Value</b>	<b>Description</b>
C 1	5-00002-501	100P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 2	5-00002-501	100P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 3	5-00063-513	.0033U	Capacitor, Mylar/Poly, 50V, 5%, Rad
C 4	5-00076-515	3.3U	Capacitor, Mylar/Poly, 50V, 10%, Rad
C 5	5-00002-501	100P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 6	5-00002-501	100P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 7	5-00069-513	.1U	Capacitor, Mylar/Poly, 50V, 5%, Rad
C 8	5-00002-501	100P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 9	5-00061-513	.001U	Capacitor, Mylar/Poly, 50V, 5%, Rad
C 10	5-00065-513	.01U	Capacitor, Mylar/Poly, 50V, 5%, Rad
C 11	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 12	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 13	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 14	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 15	5-00023-529	.1U	Cap, Monolithic Ceramic, 50V, 20%, Z5U
C 16	5-00023-529	.1U	Cap, Monolithic Ceramic, 50V, 20%, Z5U
C 17	5-00023-529	.1U	Cap, Monolithic Ceramic, 50V, 20%, Z5U
C 18	5-00023-529	.1U	Cap, Monolithic Ceramic, 50V, 20%, Z5U
C 19	5-00023-529	.1U	Cap, Monolithic Ceramic, 50V, 20%, Z5U
C 20	5-00023-529	.1U	Cap, Monolithic Ceramic, 50V, 20%, Z5U
C 21	5-00023-529	.1U	Cap, Monolithic Ceramic, 50V, 20%, Z5U
C 22	5-00023-529	.1U	Cap, Monolithic Ceramic, 50V, 20%, Z5U
C 23	5-00023-529	.1U	Cap, Monolithic Ceramic, 50V, 20%, Z5U
C 24	5-00023-529	.1U	Cap, Monolithic Ceramic, 50V, 20%, Z5U
C 25	5-00008-501	22P	Capacitor, Ceramic Disc, 50V, 10%, SL
D 22	3-00004-301	1N4148	Diode
D 24	3-00011-303	RED	LED, T1 Package
P 1	4-00010-440	50K	Trim Pot, Single Turn, In-Line Leads
P 2	4-00010-440	50K	Trim Pot, Single Turn, In-Line Leads
P 3	4-00010-440	50K	Trim Pot, Single Turn, In-Line Leads
P 4	4-00009-440	500K	Trim Pot, Single Turn, In-Line Leads
P 5	4-00003-440	100K	Trim Pot, Single Turn, In-Line Leads
P 6	4-00009-440	500K	Trim Pot, Single Turn, In-Line Leads
P 7	4-00006-440	20	Trim Pot, Single Turn, In-Line Leads
PC1	7-00029-701	SR235	Printed Circuit Board
R 1	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 2	4-00131-407	1.00M	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 3	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 4	4-00131-407	1.00M	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 5	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 6	4-00138-407	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 7	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 8	4-00138-407	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 9	4-00138-407	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 10	4-00138-407	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 11	4-00138-407	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 12	4-00138-407	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM

<u>Ref.</u>	<u>SRS Part#</u>	<u>Value</u>	<u>Description</u>
R 13	4-00138-407	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 14	4-00138-407	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 15	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 16	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 17	4-00021-401	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 18	4-00082-401	470K	Resistor, Carbon Film, 1/4W, 5%
R 19	4-00138-407	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 20	4-00138-407	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 21	4-00102-401	75K	Resistor, Carbon Film, 1/4W, 5%
R 22	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 23	4-00218-408	10.00K	Resistor, Metal Film, 1/8W, 0.1%, 25ppm
R 24	4-00219-408	20.00K	Resistor, Metal Film, 1/8W, 0.1%, 25ppm
R 25	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 26	4-00055-401	20K	Resistor, Carbon Film, 1/4W, 5%
R 27	4-00032-401	100K	Resistor, Carbon Film, 1/4W, 5%
R 28	4-00219-408	20.00K	Resistor, Metal Film, 1/8W, 0.1%, 25ppm
R 29	4-00218-408	10.00K	Resistor, Metal Film, 1/8W, 0.1%, 25ppm
R 30	4-00219-408	20.00K	Resistor, Metal Film, 1/8W, 0.1%, 25ppm
R 31	4-00218-408	10.00K	Resistor, Metal Film, 1/8W, 0.1%, 25ppm
R 32	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 33	4-00102-401	75K	Resistor, Carbon Film, 1/4W, 5%
R 34	4-00070-401	30K	Resistor, Carbon Film, 1/4W, 5%
R 35	4-00035-401	10M	Resistor, Carbon Film, 1/4W, 5%
R 36	4-00064-401	3.0M	Resistor, Carbon Film, 1/4W, 5%
R 37	4-00022-401	1.0M	Resistor, Carbon Film, 1/4W, 5%
R 38	4-00069-401	300K	Resistor, Carbon Film, 1/4W, 5%
R 39	4-00032-401	100K	Resistor, Carbon Film, 1/4W, 5%
R 40	4-00138-407	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 41	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 42	4-00138-407	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 43	4-00083-401	47K	Resistor, Carbon Film, 1/4W, 5%
R 44	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 45	4-00091-401	560K	Resistor, Carbon Film, 1/4W, 5%
R 46	4-00165-407	200	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 47	4-00213-407	90.9	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 48	4-00213-407	90.9	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 49	4-00228-430	10K	Thermistor PTC, 0.7% Degree Centigrade
R 50	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 51	4-00073-401	330K	Resistor, Carbon Film, 1/4W, 5%
R 52	4-00091-401	560K	Resistor, Carbon Film, 1/4W, 5%
R 53	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 54	4-00083-401	47K	Resistor, Carbon Film, 1/4W, 5%
R 55	4-00032-401	100K	Resistor, Carbon Film, 1/4W, 5%
R 56	4-00021-401	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 57	4-00035-401	10M	Resistor, Carbon Film, 1/4W, 5%
R 58	4-00032-401	100K	Resistor, Carbon Film, 1/4W, 5%
R 59	4-00142-407	100K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 60	4-00192-407	49.9K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 61	4-00164-407	20.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM

<b><u>Ref.</u></b>	<b><u>SRS Part#</u></b>	<b><u>Value</u></b>	<b><u>Description</u></b>
R 62	4-00138-407	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 63	4-00188-407	4.99K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 64	4-00158-407	2.00K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 65	4-00130-407	1.00K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 66	4-00193-407	499	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 67	4-00138-407	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 68	4-00138-407	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 69	4-00138-407	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 70	4-00037-401	11K	Resistor, Carbon Film, 1/4W, 5%
R 71	4-00042-401	15K	Resistor, Carbon Film, 1/4W, 5%
R 72	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 73	4-00042-401	15K	Resistor, Carbon Film, 1/4W, 5%
R 74	4-00037-401	11K	Resistor, Carbon Film, 1/4W, 5%
R 75	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 76	4-00022-401	1.0M	Resistor, Carbon Film, 1/4W, 5%
R 77	4-00032-401	100K	Resistor, Carbon Film, 1/4W, 5%
R 78	4-00032-401	100K	Resistor, Carbon Film, 1/4W, 5%
R 79	4-00022-401	1.0M	Resistor, Carbon Film, 1/4W, 5%
R 80	4-00021-401	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 81	4-00057-401	220	Resistor, Carbon Film, 1/4W, 5%
SW1	2-00020-210	4P6T	Switch, Rotary, PCB Mounted
SW2	2-00019-210	2P12T	Switch, Rotary, PCB Mounted
SW3	2-00020-210	4P6T	Switch, Rotary, PCB Mounted
SW4	2-00018-210	1P12T	Switch, Rotary, PCB Mounted
U 1	3-00091-340	LF412	Integrated Circuit (Thru-hole Pkg)
U 2	3-00091-340	LF412	Integrated Circuit (Thru-hole Pkg)
U 3	3-00091-340	LF412	Integrated Circuit (Thru-hole Pkg)
U 4	3-00091-340	LF412	Integrated Circuit (Thru-hole Pkg)
U 5	3-00091-340	LF412	Integrated Circuit (Thru-hole Pkg)
U 6	3-00091-340	LF412	Integrated Circuit (Thru-hole Pkg)
U 7	3-00091-340	LF412	Integrated Circuit (Thru-hole Pkg)
U 8	3-00091-340	LF412	Integrated Circuit (Thru-hole Pkg)
U 9	3-00091-340	LF412	Integrated Circuit (Thru-hole Pkg)
U 10	3-00091-340	LF412	Integrated Circuit (Thru-hole Pkg)
U 11	3-00091-340	LF412	Integrated Circuit (Thru-hole Pkg)
U 12	3-00091-340	LF412	Integrated Circuit (Thru-hole Pkg)
U 13	3-00087-340	LF347	Integrated Circuit (Thru-hole Pkg)
U 14	3-00063-340	CA3046	Integrated Circuit (Thru-hole Pkg)
U 15	3-00063-340	CA3046	Integrated Circuit (Thru-hole Pkg)
U 16	3-00057-340	AD534	Integrated Circuit (Thru-hole Pkg)
U 17	3-00120-329	7915	Voltage Reg., TO-220 (TAB) Package
U 18	3-00114-329	7815	Voltage Reg., TO-220 (TAB) Package
U 19	3-00418-340	TND907/MAD1108	Integrated Circuit (Thru-hole Pkg)
U 20	3-00418-340	TND907/MAD1108	Integrated Circuit (Thru-hole Pkg)
U 21	3-00418-340	TND907/MAD1108	Integrated Circuit (Thru-hole Pkg)
Z 0	0-00022-004	KLN500B1/8	Knobs
Z 0	0-00030-060	NIM FP	Screw, Misc
Z 0	0-00031-006	200833-2	NIM (Nuclear Instrumentation Module)
Z 0	0-00032-006	202394-2	NIM (Nuclear Instrumentation Module)

<u>Ref.</u>	<u>SRS Part#</u>	<u>Value</u>	<u>Description</u>
Z 0	0-00034-006	202514-1	NIM (Nuclear Instrumentation Module)
Z 0	0-00036-006	203964-5	NIM (Nuclear Instrumentation Module)
Z 0	0-00037-006	204186-5	NIM (Nuclear Instrumentation Module)
Z 0	0-00040-006	66103-4	NIM (Nuclear Instrumentation Module)
Z 0	0-00043-011	4-40 KEP	Nut, Kep
Z 0	0-00061-061	4-40X3/8B	Screw, Binding Head, Slotted
Z 0	0-00089-033	4"	Tie
Z 0	0-00098-042	#6 LOCK	Washer, lock
Z 0	0-00100-040	1/4X1/16	Washer, Flat
Z 0	0-00101-040	1/4X1/32	Washer, Flat
Z 0	0-00108-054	1" #26	Wire #26 UL1061
Z 0	0-00128-053	4" #24	Wire #24 UL1007 Strip 1/4x1/4 Tin
Z 0	0-00140-009	SHEET	Mylar Sheet
Z 0	0-00187-021	4-40X1/4PP	Screw, Panhead Phillips
Z 0	0-00229-031	6-32 NIM FP	Standoff
Z 0	0-00230-061	4-40X1/4B	Screw, Binding Head, Slotted
Z 0	1-00003-120	BNC	Connector, BNC
Z 0	7-00013-710	SR235	Front Panel
Z 0	7-00084-711	22-001	Rear Panel
Z 0	7-00087-712	SR200-8	Side Panel
Z 0	7-00088-720	SR200-12	Fabricated Part
Z 0	7-00091-720	25-001	Fabricated Part
Z 0	7-00094-714	26-001	Extrusion
Z 0	7-00096-714	SR200-9	Extrusion
Z 0	9-00267-917	GENERIC	Product Labels

**Model SR245 Parts List**

<b><u>Ref.</u></b>	<b><u>SRS Part#</u></b>	<b><u>Value</u></b>	<b><u>Description</u></b>
C 1	5-00007-501	220P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 2	5-00007-501	220P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 3	5-00192-542	22U MIN	Cap, Mini Electrolytic, 50V, 20% Radial
C 4	5-00008-501	22P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 5	5-00068-513	.047U	Capacitor, Mylar/Poly, 50V, 5%, Rad
C 6	5-00068-513	.047U	Capacitor, Mylar/Poly, 50V, 5%, Rad
C 7	5-00068-513	.047U	Capacitor, Mylar/Poly, 50V, 5%, Rad
C 8	5-00068-513	.047U	Capacitor, Mylar/Poly, 50V, 5%, Rad
C 9	5-00068-513	.047U	Capacitor, Mylar/Poly, 50V, 5%, Rad
C 10	5-00068-513	.047U	Capacitor, Mylar/Poly, 50V, 5%, Rad
C 11	5-00068-513	.047U	Capacitor, Mylar/Poly, 50V, 5%, Rad
C 12	5-00068-513	.047U	Capacitor, Mylar/Poly, 50V, 5%, Rad
C 13	5-00010-501	270P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 14	5-00010-501	270P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 15	5-00010-501	270P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 16	5-00010-501	270P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 17	5-00010-501	270P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 18	5-00010-501	270P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 19	5-00010-501	270P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 20	5-00010-501	270P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 21	5-00108-519	.0047U	Capacitor, Polystyrene, 50V, 5%, Rad
C 22	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 23	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 24	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 25	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 26	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 27	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 28	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C 29	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C 30	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C 31	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C 32	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C 33	5-00007-501	220P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 34	5-00002-501	100P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 35	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C 36	6-00000-600	DELETED	Misc. Components
C 37	5-00041-509	220U	Capacitor, Electrolytic, 50V, 20%, Rad
C 38	5-00192-542	22U MIN	Cap, Mini Electrolytic, 50V, 20% Radial
C 39	5-00192-542	22U MIN	Cap, Mini Electrolytic, 50V, 20% Radial
C 40	5-00192-542	22U MIN	Cap, Mini Electrolytic, 50V, 20% Radial
CX100	5-00010-501	270P	Capacitor, Ceramic Disc, 50V, 10%, SL
D 1	3-00001-301	1N4001	Diode
D 2	3-00010-303	GREEN	LED, T1 Package
D 3	3-00011-303	RED	LED, T1 Package
D 4	3-00226-301	1N5822	Diode
H 1	1-00017-132	16 DIP	Header, DIP
J 1	1-00008-130	20 PIN DI	Connector, Male

<u>Ref.</u>	<u>SRS Part#</u>	<u>Value</u>	<u>Description</u>
J 2	1-00016-160	RS232 25 PIN D	Connector, D-Sub, Right Angle PC, Female
J 3	1-00238-161	GPIO SHIELDED	Connector, IEEE488, Reverse, R/A, Female
P 1	4-00002-440	100	Trim Pot, Single Turn, In-Line Leads
P 2	4-00002-440	100	Trim Pot, Single Turn, In-Line Leads
PC1	7-00030-701	SR245	Printed Circuit Board
Q 1	3-00020-325	PN2222	Transistor, TO-92 Package
Q 2	3-00020-325	PN2222	Transistor, TO-92 Package
Q 3	3-00020-325	PN2222	Transistor, TO-92 Package
Q 4	3-00020-325	PN2222	Transistor, TO-92 Package
R 1	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 2	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 3	4-00021-401	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 4	4-00112-402	47	Resistor, Carbon Comp, 1/2W, 5%
R 5	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 6	4-00112-402	47	Resistor, Carbon Comp, 1/2W, 5%
R 7	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 8	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 9	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 10	4-00218-408	10.00K	Resistor, Metal Film, 1/8W, 0.1%, 25ppm
R 11	4-00218-408	10.00K	Resistor, Metal Film, 1/8W, 0.1%, 25ppm
R 12	4-00078-401	39K	Resistor, Carbon Film, 1/4W, 5%
R 13	4-00059-401	22K	Resistor, Carbon Film, 1/4W, 5%
R 14	4-00032-401	100K	Resistor, Carbon Film, 1/4W, 5%
R 15	4-00021-401	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 16	4-00021-401	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 17	4-00021-401	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 18	4-00048-401	2.2K	Resistor, Carbon Film, 1/4W, 5%
R 19	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 20	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 21	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 22	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 23	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 24	4-00048-401	2.2K	Resistor, Carbon Film, 1/4W, 5%
R 25	4-00021-401	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 26	4-00021-401	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 27	4-00021-401	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 28	4-00021-401	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 29	4-00021-401	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 30	4-00021-401	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 31	4-00021-401	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 32	4-00021-401	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 33	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 34	4-00537-451	1	Resistor, Carbon Film, 1W
R 35	4-00537-451	1	Resistor, Carbon Film, 1W
R 36	4-00030-401	10	Resistor, Carbon Film, 1/4W, 5%
R 37	4-00030-401	10	Resistor, Carbon Film, 1/4W, 5%
R 38	4-00030-401	10	Resistor, Carbon Film, 1/4W, 5%
R 39	4-00030-401	10	Resistor, Carbon Film, 1/4W, 5%
R 40	4-00030-401	10	Resistor, Carbon Film, 1/4W, 5%

<u>Ref.</u>	<u>SRS Part#</u>	<u>Value</u>	<u>Description</u>
R 41	4-00030-401	10	Resistor, Carbon Film, 1/4W, 5%
R 43	4-00028-401	1.5M	Resistor, Carbon Film, 1/4W, 5%
RN1	4-00225-425	100KX9	Resistor Network SIP 1/4W 2% (Common)
RN3	4-00220-420	10KX8	Resistor Network, DIP, 1/4W,2%,8 Ind
RN4	4-00224-425	1.0MX9	Resistor Network SIP 1/4W 2% (Common)
RN5	4-00220-420	10KX8	Resistor Network, DIP, 1/4W,2%,8 Ind
SO2	1-00026-150	28 PIN 600 MIL	Socket, THRU-HOLE
SO40	1-00022-150	16 PIN 300 MIL	Socket, THRU-HOLE
SO41	1-00022-150	16 PIN 300 MIL	Socket, THRU-HOLE
SW1	6-00000-600	DELETED	Misc. Components
SW2	2-00009-207	SPSTX8	Switch, DIP
U 1	3-01438-340	Z84C0006PEC	Integrated Circuit (Thru-hole Pkg)
U 2	3-00305-342	27C64-255	EPROM/PROM, I.C.
U 3	3-00157-341	8KX8-100 LOW	STATIC RAM, I.C.
U 4	3-00493-340	UPD71051C	Integrated Circuit (Thru-hole Pkg)
U 5	3-00491-340	UPD71054C	Integrated Circuit (Thru-hole Pkg)
U 6	3-00111-340	MC68B488	Integrated Circuit (Thru-hole Pkg)
U 7	3-00078-340	DS75160A	Integrated Circuit (Thru-hole Pkg)
U 8	3-00079-340	DS75161A	Integrated Circuit (Thru-hole Pkg)
U 9	3-00048-340	74HC73	Integrated Circuit (Thru-hole Pkg)
U 10	3-00048-340	74HC73	Integrated Circuit (Thru-hole Pkg)
U 11	3-00037-340	74HC138	Integrated Circuit (Thru-hole Pkg)
U 12	3-00044-340	74HC244	Integrated Circuit (Thru-hole Pkg)
U 13	3-00044-340	74HC244	Integrated Circuit (Thru-hole Pkg)
U 14	3-00044-340	74HC244	Integrated Circuit (Thru-hole Pkg)
U 15	3-00046-340	74HC374	Integrated Circuit (Thru-hole Pkg)
U 16	3-00046-340	74HC374	Integrated Circuit (Thru-hole Pkg)
U 17	3-00051-340	74HCU04	Integrated Circuit (Thru-hole Pkg)
U 18	3-00045-340	74HC32	Integrated Circuit (Thru-hole Pkg)
U 19	3-00045-340	74HC32	Integrated Circuit (Thru-hole Pkg)
U 20	3-00059-340	7542	Integrated Circuit (Thru-hole Pkg)
U 21	3-00076-340	DG211	Integrated Circuit (Thru-hole Pkg)
U 22	3-00077-340	DG528	Integrated Circuit (Thru-hole Pkg)
U 23	3-00077-340	DG528	Integrated Circuit (Thru-hole Pkg)
U 24	8-00089-860	SR246	SRS sub assemblies
U 26	3-00087-340	LF347	Integrated Circuit (Thru-hole Pkg)
U 27	3-00087-340	LF347	Integrated Circuit (Thru-hole Pkg)
U 28	3-00087-340	LF347	Integrated Circuit (Thru-hole Pkg)
U 29	3-00087-340	LF347	Integrated Circuit (Thru-hole Pkg)
U 30	3-00087-340	LF347	Integrated Circuit (Thru-hole Pkg)
U 31	3-00094-340	LM311	Integrated Circuit (Thru-hole Pkg)
U 32	3-00058-340	AD7524	Integrated Circuit (Thru-hole Pkg)
U 33	3-00114-329	7815	Voltage Reg., TO-220 (TAB) Package
U 34	3-00120-329	7915	Voltage Reg., TO-220 (TAB) Package
U 35	3-00112-329	7805	Voltage Reg., TO-220 (TAB) Package
U 36	3-00110-340	MC1489	Integrated Circuit (Thru-hole Pkg)
U 37	3-00109-340	MC1488	Integrated Circuit (Thru-hole Pkg)
U 38	3-00092-340	LH0071	Integrated Circuit (Thru-hole Pkg)
X 1	6-00010-620	4.000 MHZ	Crystal

<u>Ref.</u>	<u>SRS Part#</u>	<u>Value</u>	<u>Description</u>
Z 0	0-00030-060	NIM FP	Screw, Misc
Z 0	0-00031-006	200833-2	NIM (Nuclear Instrumentation Module)
Z 0	0-00032-006	202394-2	NIM (Nuclear Instrumentation Module)
Z 0	0-00034-006	202514-1	NIM (Nuclear Instrumentation Module)
Z 0	0-00036-006	203964-5	NIM (Nuclear Instrumentation Module)
Z 0	0-00037-006	204186-5	NIM (Nuclear Instrumentation Module)
Z 0	0-00040-006	66103-4	NIM (Nuclear Instrumentation Module)
Z 0	0-00043-011	4-40 KEP	Nut, Kep
Z 0	0-00061-061	4-40X3/8B	Screw, Binding Head, Slotted
Z 0	0-00079-031	4-40X3/16 M/F	Standoff
Z 0	0-00089-033	4"	Tie
Z 0	0-00108-054	1" #26	Wire #26 UL1061
Z 0	0-00117-053	12" #24	Wire #24 UL1007 Strip 1/4x1/4 Tin
Z 0	0-00140-009	SHEET	Mylar Sheet
Z 0	0-00187-021	4-40X1/4PP	Screw, Panhead Phillips
Z 0	0-00207-003	TO-5	Insulators
Z 0	0-00229-031	6-32 NIM FP	Standoff
Z 0	0-00230-061	4-40X1/4B	Screw, Binding Head, Slotted
Z 0	0-00500-000	554808-1	Hardware, Misc.
Z 0	0-00532-053	3-1/2 YEL NOTIN	Wire #24 UL1007 Strip 1/4x1/4 Tin
Z 0	0-00533-053	2-1/4 RED NOTIN	Wire #24 UL1007 Strip 1/4x1/4 Tin
Z 0	1-00003-120	BNC	Connector, BNC
Z 0	1-00145-131	20 PIN DIF POL	Connector, Female
Z 0	7-00014-710	SR245-4	Front Panel
Z 0	7-00042-711	SR245-5	Rear Panel
Z 0	7-00078-714	SR200-13	Extrusion
Z 0	7-00087-712	SR200-8	Side Panel
Z 0	7-00088-720	SR200-12	Fabricated Part
Z 0	7-00091-720	25-001	Fabricated Part
Z 0	7-00094-714	26-001	Extrusion
Z 0	9-00267-917	GENERIC	Product Labels



**Model SR250 Parts List**

<b>Ref.</b>	<b>SRS Part#</b>	<b>Value</b>	<b>Description</b>
C 1	5-00017-501	47P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 2	5-00007-501	220P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 3	5-00023-529	.1U	Cap, Monolithic Ceramic, 50V, 20%, Z5U
C 4	5-00003-501	10P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 5	5-00022-501	.001U	Capacitor, Ceramic Disc, 50V, 10%, SL
C 6	5-00068-513	.047U	Capacitor, Mylar/Poly, 50V, 5%, Rad
C 7	5-00027-503	.01U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 8	5-00002-501	100P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 9	5-00003-501	10P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 10	5-00027-503	.01U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 11	5-00018-501	5P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 12	5-00009-501	24P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 100	6-00000-600	DELETED	Misc. Components
C 101	5-00080-516	180P	Capacitor, Silver Mica, 500V, 5%,
C 102	5-00062-513	.0022U	Capacitor, Mylar/Poly, 50V, 5%, Rad
C 103	5-00066-513	.022U	Capacitor, Mylar/Poly, 50V, 5%, Rad
C 104	5-00070-513	.22U	Capacitor, Mylar/Poly, 50V, 5%, Rad
C 105	5-00101-517	2.2U SEL	Capacitor, Tantalum, 35V, 20%, Rad
C 106	5-00192-542	22U MIN	Cap, Mini Electrolytic, 50V, 20% Radial
C 107	5-00041-509	220U	Capacitor, Electrolytic, 50V, 20%, Rad
C 109	6-00022-600	SELECTED	Misc. Components
C 110	5-00003-501	10P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 111	5-00003-501	10P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 112	6-00000-600	DELETED	Misc. Components
C 113	5-00002-501	100P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 114	5-00002-501	100P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 115	5-00061-513	.001U	Capacitor, Mylar/Poly, 50V, 5%, Rad
C 116	5-00074-515	.015U	Capacitor, Mylar/Poly, 50V, 10%, Rad
C 117	5-00093-517	.15U	Capacitor, Tantalum, 35V, 20%, Rad
C 118	5-00097-517	1.5U	Capacitor, Tantalum, 35V, 20%, Rad
C 119	5-00077-516	100P	Capacitor, Silver Mica, 500V, 5%,
C 120	5-00061-513	.001U	Capacitor, Mylar/Poly, 50V, 5%, Rad
C 121	5-00104-530	3.5-20P	Capacitor, Variable, Misc.
C 122	5-00091-516	82P	Capacitor, Silver Mica, 500V, 5%,
C 123	5-00085-516	300P	Capacitor, Silver Mica, 500V, 5%,
C 124	5-00061-513	.001U	Capacitor, Mylar/Poly, 50V, 5%, Rad
C 125	5-00063-513	.0033U	Capacitor, Mylar/Poly, 50V, 5%, Rad
C 126	5-00065-513	.01U	Capacitor, Mylar/Poly, 50V, 5%, Rad
C 127	5-00067-513	.033U	Capacitor, Mylar/Poly, 50V, 5%, Rad
C 128	6-00022-600	SELECTED	Misc. Components
C 129	6-00022-600	SELECTED	Misc. Components
C 130	6-00022-600	SELECTED	Misc. Components
C 131	6-00022-600	SELECTED	Misc. Components
C 132	6-00022-600	SELECTED	Misc. Components
C 133	6-00022-600	SELECTED	Misc. Components
C 134	5-00027-503	.01U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 135	5-00003-501	10P	Capacitor, Ceramic Disc, 50V, 10%, SL

<u>Ref.</u>	<u>SRS Part#</u>	<u>Value</u>	<u>Description</u>
C 136	5-00003-501	10P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 137	5-00027-503	.01U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 138	5-00027-503	.01U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 139	5-00008-501	22P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 140	5-00009-501	24P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 141	5-00003-501	10P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 145	5-00003-501	10P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 201	5-00065-513	.01U	Capacitor, Mylar/Poly, 50V, 5%, Rad
C 202	5-00061-513	.001U	Capacitor, Mylar/Poly, 50V, 5%, Rad
C 203	5-00088-516	470P	Capacitor, Silver Mica, 500V, 5%,
C 204	5-00023-529	.1U	Cap, Monolithic Ceramic, 50V, 20%, Z5U
C 205	5-00023-529	.1U	Cap, Monolithic Ceramic, 50V, 20%, Z5U
C 206	5-00027-503	.01U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 207	5-00027-503	.01U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 208	6-00000-600	DELETED	Misc. Components
C 209	5-00015-501	39P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 210	5-00027-503	.01U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 211	5-00027-503	.01U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 212	5-00090-516	56P	Capacitor, Silver Mica, 500V, 5%,
C 213	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 214	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 215	5-00011-501	27P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 216	5-00003-501	10P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 217	6-00000-600	DELETED	Misc. Components
C 218	5-00027-503	.01U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 219	5-00079-516	150P	Capacitor, Silver Mica, 500V, 5%,
C 220	5-00061-513	.001U	Capacitor, Mylar/Poly, 50V, 5%, Rad
C 221	5-00063-513	.0033U	Capacitor, Mylar/Poly, 50V, 5%, Rad
C 222	5-00065-513	.01U	Capacitor, Mylar/Poly, 50V, 5%, Rad
C 223	5-00067-513	.033U	Capacitor, Mylar/Poly, 50V, 5%, Rad
C 224	5-00069-513	.1U	Capacitor, Mylar/Poly, 50V, 5%, Rad
C 225	5-00058-512	.33U	Cap, Stacked Metal Film 50V 5% -40/+85c
C 226	5-00018-501	5P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 227	5-00016-501	470P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 228	5-00012-501	330P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 229	5-00013-501	33P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 230	5-00027-503	.01U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 231	5-00027-503	.01U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 232	5-00023-529	.1U	Cap, Monolithic Ceramic, 50V, 20%, Z5U
C 233	5-00006-501	15P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 234	5-00016-501	470P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 235	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 300	5-00064-513	.0047U	Capacitor, Mylar/Poly, 50V, 5%, Rad
C 301	5-00068-513	.047U	Capacitor, Mylar/Poly, 50V, 5%, Rad
C 302	5-00073-513	4.7U	Capacitor, Mylar/Poly, 50V, 5%, Rad
C 303	5-00027-503	.01U	Capacitor, Ceramic Disc, 50V, 20%, Z5U
C 304	5-00062-513	.0022U	Capacitor, Mylar/Poly, 50V, 5%, Rad
C 305	5-00002-501	100P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 306	5-00002-501	100P	Capacitor, Ceramic Disc, 50V, 10%, SL

<u>Ref.</u>	<u>SRS Part#</u>	<u>Value</u>	<u>Description</u>
C 307	5-00061-513	.001U	Capacitor, Mylar/Poly, 50V, 5%, Rad
C 308	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C 309	6-00000-600	DELETED	Misc. Components
C 400	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C 401	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C 402	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C 403	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C 404	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C 405	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C 406	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C 407	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C 408	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C 409	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C 410	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C 411	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C 412	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C 413	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C 414	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C 415	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C 416	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C 417	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C 418	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C 419	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 420	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 421	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 422	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 423	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 424	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 425	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 426	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 427	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C 428	5-00098-517	10U	Capacitor, Tantalum, 35V, 20%, Rad
CX8	5-00012-501	330P	Capacitor, Ceramic Disc, 50V, 10%, SL
D 1	3-00004-301	1N4148	Diode
D 2	3-00004-301	1N4148	Diode
D 3	3-00006-301	1N746A	Diode
D 4	3-00004-301	1N4148	Diode
D 6	3-00004-301	1N4148	Diode
D 7	3-00004-301	1N4148	Diode
D 8	3-00004-301	1N4148	Diode
D 9	3-00004-301	1N4148	Diode
D 10	3-00010-303	GREEN	LED, T1 Package
D 11	3-00011-303	RED	LED, T1 Package
D 12	3-00004-301	1N4148	Diode
DL1	0-00051-056	RG174	Cable, Coax & Misc.
DL2	0-00051-056	RG174	Cable, Coax & Misc.
DL3	0-00051-056	RG174	Cable, Coax & Misc.
L 1	6-00006-602	33U	Inductor, Radial
L 2	6-00006-602	33U	Inductor, Radial

<u>Ref.</u>	<u>SRS Part#</u>	<u>Value</u>	<u>Description</u>
P 1	4-00018-442	50K	Pot, Dual Control
P 2	4-00018-442	50K	Pot, Dual Control
P 3	4-00019-443	20K	Pot, 10-Turn Panel
P 4	4-00004-440	10K	Trim Pot, Single Turn, In-Line Leads
P 5	4-00004-440	10K	Trim Pot, Single Turn, In-Line Leads
P 6	4-00003-440	100K	Trim Pot, Single Turn, In-Line Leads
P 7	4-00005-440	2.0K	Trim Pot, Single Turn, In-Line Leads
P 8	4-00004-440	10K	Trim Pot, Single Turn, In-Line Leads
P 9	4-00008-440	500	Trim Pot, Single Turn, In-Line Leads
P 10	4-00004-440	10K	Trim Pot, Single Turn, In-Line Leads
P 11	4-00003-440	100K	Trim Pot, Single Turn, In-Line Leads
P 12	4-00008-440	500	Trim Pot, Single Turn, In-Line Leads
P 13	4-00005-440	2.0K	Trim Pot, Single Turn, In-Line Leads
P 14	4-00019-443	20K	Pot, 10-Turn Panel
PC1	7-00031-701	SR250	Printed Circuit Board
Q 1	3-00029-325	2N5951	Transistor, TO-92 Package
Q 2	3-00028-325	2N5771	Transistor, TO-92 Package
Q 3	3-00028-325	2N5771	Transistor, TO-92 Package
Q 4	3-00028-325	2N5771	Transistor, TO-92 Package
Q 5	3-00027-325	2N5770	Transistor, TO-92 Package
Q 6	3-00027-325	2N5770	Transistor, TO-92 Package
Q 7	3-00028-325	2N5771	Transistor, TO-92 Package
Q 8	3-00028-325	2N5771	Transistor, TO-92 Package
Q 10	3-00028-325	2N5771	Transistor, TO-92 Package
Q 11	3-00028-325	2N5771	Transistor, TO-92 Package
Q 12	3-00027-325	2N5770	Transistor, TO-92 Package
Q 13	3-00027-325	2N5770	Transistor, TO-92 Package
Q 14	3-00028-325	2N5771	Transistor, TO-92 Package
Q 15	3-00028-325	2N5771	Transistor, TO-92 Package
Q 16	3-00028-325	2N5771	Transistor, TO-92 Package
Q 17	3-00028-325	2N5771	Transistor, TO-92 Package
Q 20	3-00030-325	J310	Transistor, TO-92 Package
Q 21	3-00028-325	2N5771	Transistor, TO-92 Package
Q 22	3-00027-325	2N5770	Transistor, TO-92 Package
Q 23	3-00017-324	MM4049	Transistor, TO-72 Package
Q 24	3-00017-324	MM4049	Transistor, TO-72 Package
Q 25	3-00017-324	MM4049	Transistor, TO-72 Package
Q 26	3-00018-324	MRF904	Transistor, TO-72 Package
Q 27	3-00018-324	MRF904	Transistor, TO-72 Package
Q 28	3-00018-324	MRF904	Transistor, TO-72 Package
Q 29	3-00032-326	MRF901	Transistor, Micro Strip Package
Q 30	3-00032-326	MRF901	Transistor, Micro Strip Package
Q 31	3-00021-325	2N3904	Transistor, TO-92 Package
Q 32	3-00022-325	2N3906	Transistor, TO-92 Package
Q 33	3-00022-325	2N3906	Transistor, TO-92 Package
R 1	4-00022-401	1.0M	Resistor, Carbon Film, 1/4W, 5%
R 2	4-00022-401	1.0M	Resistor, Carbon Film, 1/4W, 5%
R 3	4-00057-401	220	Resistor, Carbon Film, 1/4W, 5%
R 4	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%

<u>Ref.</u>	<u>SRS Part#</u>	<u>Value</u>	<u>Description</u>
R 5	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 6	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 7	4-00090-401	560	Resistor, Carbon Film, 1/4W, 5%
R 8	4-00089-401	56	Resistor, Carbon Film, 1/4W, 5%
R 9	4-00089-401	56	Resistor, Carbon Film, 1/4W, 5%
R 10	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 11	4-00031-401	100	Resistor, Carbon Film, 1/4W, 5%
R 12	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 13	4-00031-401	100	Resistor, Carbon Film, 1/4W, 5%
R 14	4-00048-401	2.2K	Resistor, Carbon Film, 1/4W, 5%
R 15	4-00031-401	100	Resistor, Carbon Film, 1/4W, 5%
R 16	4-00081-401	470	Resistor, Carbon Film, 1/4W, 5%
R 17	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 18	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 19	4-00090-401	560	Resistor, Carbon Film, 1/4W, 5%
R 20	4-00079-401	4.7K	Resistor, Carbon Film, 1/4W, 5%
R 21	4-00073-401	330K	Resistor, Carbon Film, 1/4W, 5%
R 22	4-00048-401	2.2K	Resistor, Carbon Film, 1/4W, 5%
R 23	4-00035-401	10M	Resistor, Carbon Film, 1/4W, 5%
R 24	4-00066-401	3.3M	Resistor, Carbon Film, 1/4W, 5%
R 25	4-00022-401	1.0M	Resistor, Carbon Film, 1/4W, 5%
R 26	4-00073-401	330K	Resistor, Carbon Film, 1/4W, 5%
R 27	4-00032-401	100K	Resistor, Carbon Film, 1/4W, 5%
R 28	4-00074-401	33K	Resistor, Carbon Film, 1/4W, 5%
R 29	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 30	4-00065-401	3.3K	Resistor, Carbon Film, 1/4W, 5%
R 31	4-00021-401	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 32	4-00059-401	22K	Resistor, Carbon Film, 1/4W, 5%
R 33	4-00059-401	22K	Resistor, Carbon Film, 1/4W, 5%
R 34	4-00081-401	470	Resistor, Carbon Film, 1/4W, 5%
R 35	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 36	4-00090-401	560	Resistor, Carbon Film, 1/4W, 5%
R 37	4-00089-401	56	Resistor, Carbon Film, 1/4W, 5%
R 38	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 39	4-00076-401	390	Resistor, Carbon Film, 1/4W, 5%
R 40	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 41	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 42	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 43	4-00048-401	2.2K	Resistor, Carbon Film, 1/4W, 5%
R 44	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 45	4-00021-401	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 46	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 47	4-00122-405	47	Resistor, Carbon Film, 1/8W, 5%
R 48	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 49	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 50	4-00048-401	2.2K	Resistor, Carbon Film, 1/4W, 5%
R 51	4-00041-401	150	Resistor, Carbon Film, 1/4W, 5%
R 52	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 53	4-00021-401	1.0K	Resistor, Carbon Film, 1/4W, 5%

<b>Ref.</b>	<b>SRS Part#</b>	<b>Value</b>	<b>Description</b>
R 54	4-00209-407	887	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 55	4-00041-401	150	Resistor, Carbon Film, 1/4W, 5%
R 56	4-00021-401	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 57	4-00027-401	1.5K	Resistor, Carbon Film, 1/4W, 5%
R 58	4-00027-401	1.5K	Resistor, Carbon Film, 1/4W, 5%
R 59	4-00021-401	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 60	4-00108-402	150	Resistor, Carbon Comp, 1/2W, 5%
R 61	4-00057-401	220	Resistor, Carbon Film, 1/4W, 5%
R 62	4-00024-401	1.2K	Resistor, Carbon Film, 1/4W, 5%
R 63	4-00089-401	56	Resistor, Carbon Film, 1/4W, 5%
R 64	4-00072-401	330	Resistor, Carbon Film, 1/4W, 5%
R 65	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 66	4-00089-401	56	Resistor, Carbon Film, 1/4W, 5%
R 67	4-00094-401	6.8K	Resistor, Carbon Film, 1/4W, 5%
R 68	4-00114-404	100K	Resistor, Carbon Comp, 1/4W, 5%
R 69	4-00114-404	100K	Resistor, Carbon Comp, 1/4W, 5%
R 100	4-00089-401	56	Resistor, Carbon Film, 1/4W, 5%
R 101	4-00081-401	470	Resistor, Carbon Film, 1/4W, 5%
R 102	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 103	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 104	4-00027-401	1.5K	Resistor, Carbon Film, 1/4W, 5%
R 105	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 106	4-00122-405	47	Resistor, Carbon Film, 1/8W, 5%
R 107	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 108	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 109	4-00048-401	2.2K	Resistor, Carbon Film, 1/4W, 5%
R 110	4-00048-401	2.2K	Resistor, Carbon Film, 1/4W, 5%
R 111	4-00048-401	2.2K	Resistor, Carbon Film, 1/4W, 5%
R 112	4-00076-401	390	Resistor, Carbon Film, 1/4W, 5%
R 113	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 114	4-00122-405	47	Resistor, Carbon Film, 1/8W, 5%
R 115	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 116	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 117	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 118	4-00103-401	820	Resistor, Carbon Film, 1/4W, 5%
R 119	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 120	4-00089-401	56	Resistor, Carbon Film, 1/4W, 5%
R 121	4-00048-401	2.2K	Resistor, Carbon Film, 1/4W, 5%
R 122	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 123	4-00089-401	56	Resistor, Carbon Film, 1/4W, 5%
R 124	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 125	4-00090-401	560	Resistor, Carbon Film, 1/4W, 5%
R 126	4-00210-407	9.09K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 127	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 128	4-00032-401	100K	Resistor, Carbon Film, 1/4W, 5%
R 129	4-00164-407	20.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 130	4-00138-407	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 131	4-00138-407	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 132	4-00138-407	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM

<u>Ref.</u>	<u>SRS Part#</u>	<u>Value</u>	<u>Description</u>
R 133	4-00138-407	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 134	4-00083-401	47K	Resistor, Carbon Film, 1/4W, 5%
R 135	4-00192-407	49.9K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 136	4-00138-407	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 137	4-00083-401	47K	Resistor, Carbon Film, 1/4W, 5%
R 138	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 139	4-00076-401	390	Resistor, Carbon Film, 1/4W, 5%
R 140	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 142	4-00089-401	56	Resistor, Carbon Film, 1/4W, 5%
R 143	4-00090-401	560	Resistor, Carbon Film, 1/4W, 5%
R 144	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 145	4-00101-401	750	Resistor, Carbon Film, 1/4W, 5%
R 146	4-00075-401	39	Resistor, Carbon Film, 1/4W, 5%
R 147	4-00081-401	470	Resistor, Carbon Film, 1/4W, 5%
R 148	4-00075-401	39	Resistor, Carbon Film, 1/4W, 5%
R 149	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 150	4-00053-401	200	Resistor, Carbon Film, 1/4W, 5%
R 151	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 152	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 153	4-00098-401	680	Resistor, Carbon Film, 1/4W, 5%
R 154	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 155	4-00056-401	22	Resistor, Carbon Film, 1/4W, 5%
R 156	4-00089-401	56	Resistor, Carbon Film, 1/4W, 5%
R 157	4-00056-401	22	Resistor, Carbon Film, 1/4W, 5%
R 158	4-00089-401	56	Resistor, Carbon Film, 1/4W, 5%
R 159	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 160	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 161	4-00026-401	1.3K	Resistor, Carbon Film, 1/4W, 5%
R 162	4-00030-401	10	Resistor, Carbon Film, 1/4W, 5%
R 163	4-00030-401	10	Resistor, Carbon Film, 1/4W, 5%
R 164	4-00021-401	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 165	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 166	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 167	4-00057-401	220	Resistor, Carbon Film, 1/4W, 5%
R 168	4-00030-401	10	Resistor, Carbon Film, 1/4W, 5%
R 169	4-00030-401	10	Resistor, Carbon Film, 1/4W, 5%
R 170	4-00057-401	220	Resistor, Carbon Film, 1/4W, 5%
R 171	4-00021-401	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 172	4-00058-401	220K	Resistor, Carbon Film, 1/4W, 5%
R 173	4-00102-401	75K	Resistor, Carbon Film, 1/4W, 5%
R 174	4-00021-401	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 175	4-00021-401	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 176	4-00089-401	56	Resistor, Carbon Film, 1/4W, 5%
R 177	4-00038-401	120	Resistor, Carbon Film, 1/4W, 5%
R 200	4-00079-401	4.7K	Resistor, Carbon Film, 1/4W, 5%
R 201	4-00079-401	4.7K	Resistor, Carbon Film, 1/4W, 5%
R 202	4-00131-407	1.00M	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 203	4-00032-401	100K	Resistor, Carbon Film, 1/4W, 5%
R 204	4-00021-401	1.0K	Resistor, Carbon Film, 1/4W, 5%

<u>Ref.</u>	<u>SRS Part#</u>	<u>Value</u>	<u>Description</u>
R 205	4-00097-401	68	Resistor, Carbon Film, 1/4W, 5%
R 206	4-00089-401	56	Resistor, Carbon Film, 1/4W, 5%
R 207	4-00081-401	470	Resistor, Carbon Film, 1/4W, 5%
R 208	4-00089-401	56	Resistor, Carbon Film, 1/4W, 5%
R 209	4-00057-401	220	Resistor, Carbon Film, 1/4W, 5%
R 210	4-00048-401	2.2K	Resistor, Carbon Film, 1/4W, 5%
R 211	4-00031-401	100	Resistor, Carbon Film, 1/4W, 5%
R 212	4-00138-407	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 213	4-00153-407	15.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 214	4-00083-401	47K	Resistor, Carbon Film, 1/4W, 5%
R 215	4-00083-401	47K	Resistor, Carbon Film, 1/4W, 5%
R 216	4-00079-401	4.7K	Resistor, Carbon Film, 1/4W, 5%
R 217	4-00079-401	4.7K	Resistor, Carbon Film, 1/4W, 5%
R 218	4-00138-407	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 219	4-00136-407	1.82K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 220	4-00154-407	150	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 221	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 222	4-00067-401	3.9K	Resistor, Carbon Film, 1/4W, 5%
R 223	4-00071-401	33	Resistor, Carbon Film, 1/4W, 5%
R 224	4-00182-407	33.2	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 225	4-00138-407	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 226	4-00138-407	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 227	4-00124-405	68	Resistor, Carbon Film, 1/8W, 5%
R 228	4-00075-401	39	Resistor, Carbon Film, 1/4W, 5%
R 229	4-00120-405	22	Resistor, Carbon Film, 1/8W, 5%
R 230	4-00075-401	39	Resistor, Carbon Film, 1/4W, 5%
R 231	4-00120-405	22	Resistor, Carbon Film, 1/8W, 5%
R 232	4-00122-405	47	Resistor, Carbon Film, 1/8W, 5%
R 233	4-00122-405	47	Resistor, Carbon Film, 1/8W, 5%
R 234	4-00122-405	47	Resistor, Carbon Film, 1/8W, 5%
R 235	4-00122-405	47	Resistor, Carbon Film, 1/8W, 5%
R 236	4-00122-405	47	Resistor, Carbon Film, 1/8W, 5%
R 237	4-00057-401	220	Resistor, Carbon Film, 1/4W, 5%
R 238	4-00122-405	47	Resistor, Carbon Film, 1/8W, 5%
R 239	4-00057-401	220	Resistor, Carbon Film, 1/4W, 5%
R 240	4-00024-401	1.2K	Resistor, Carbon Film, 1/4W, 5%
R 241	4-00081-401	470	Resistor, Carbon Film, 1/4W, 5%
R 242	4-00121-405	30	Resistor, Carbon Film, 1/8W, 5%
R 243	4-00075-401	39	Resistor, Carbon Film, 1/4W, 5%
R 244	4-00089-401	56	Resistor, Carbon Film, 1/4W, 5%
R 245	4-00075-401	39	Resistor, Carbon Film, 1/4W, 5%
R 246	4-00089-401	56	Resistor, Carbon Film, 1/4W, 5%
R 247	4-00123-405	56	Resistor, Carbon Film, 1/8W, 5%
R 248	4-00111-402	390	Resistor, Carbon Comp, 1/2W, 5%
R 249	4-00138-407	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 250	4-00182-407	33.2	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 251	4-00138-407	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 252	4-00067-401	3.9K	Resistor, Carbon Film, 1/4W, 5%
R 253	4-00071-401	33	Resistor, Carbon Film, 1/4W, 5%



<u>Ref.</u>	<u>SRS Part#</u>	<u>Value</u>	<u>Description</u>
R 254	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 255	4-00154-407	150	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 256	4-00138-407	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 257	4-00138-407	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 258	4-00021-401	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 259	4-00021-401	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 260	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 261	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 262	4-00115-404	22M	Resistor, Carbon Comp, 1/4W, 5%
R 263	4-00138-407	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 264	4-00167-407	21.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 265	4-00079-401	4.7K	Resistor, Carbon Film, 1/4W, 5%
R 266	4-00138-407	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 267	4-00142-407	100K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 268	4-00192-407	49.9K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 269	4-00164-407	20.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 270	4-00138-407	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 271	4-00188-407	4.99K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 272	4-00158-407	2.00K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 273	4-00130-407	1.00K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 274	4-00193-407	499	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 275	4-00192-407	49.9K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 276	4-00142-407	100K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 277	4-00188-407	4.99K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 279	4-00079-401	4.7K	Resistor, Carbon Film, 1/4W, 5%
R 280	4-00021-401	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 281	4-00081-401	470	Resistor, Carbon Film, 1/4W, 5%
R 282	4-00089-401	56	Resistor, Carbon Film, 1/4W, 5%
R 283	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 284	4-00119-405	150	Resistor, Carbon Film, 1/8W, 5%
R 300	4-00138-407	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 301	4-00094-401	6.8K	Resistor, Carbon Film, 1/4W, 5%
R 302	4-00138-407	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 303	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 304	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 305	4-00021-401	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 307	4-00022-401	1.0M	Resistor, Carbon Film, 1/4W, 5%
R 308	4-00090-401	560	Resistor, Carbon Film, 1/4W, 5%
R 309	4-00029-401	1.8K	Resistor, Carbon Film, 1/4W, 5%
R 310	4-00094-401	6.8K	Resistor, Carbon Film, 1/4W, 5%
R 311	4-00059-401	22K	Resistor, Carbon Film, 1/4W, 5%
R 312	4-00100-401	68K	Resistor, Carbon Film, 1/4W, 5%
R 313	4-00028-401	1.5M	Resistor, Carbon Film, 1/4W, 5%
R 314	4-00081-401	470	Resistor, Carbon Film, 1/4W, 5%
R 315	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 316	4-00081-401	470	Resistor, Carbon Film, 1/4W, 5%
R 317	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 318	4-00059-401	22K	Resistor, Carbon Film, 1/4W, 5%
R 319	4-00058-401	220K	Resistor, Carbon Film, 1/4W, 5%

<u>Ref.</u>	<u>SRS Part#</u>	<u>Value</u>	<u>Description</u>
R 320	4-00076-401	390	Resistor, Carbon Film, 1/4W, 5%
R 321	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 322	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 323	4-00021-401	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 324	4-00057-401	220	Resistor, Carbon Film, 1/4W, 5%
R 325	4-00108-402	150	Resistor, Carbon Comp, 1/2W, 5%
R 326	4-00057-401	220	Resistor, Carbon Film, 1/4W, 5%
R 327	4-00021-401	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 328	4-00072-401	330	Resistor, Carbon Film, 1/4W, 5%
R 329	4-00089-401	56	Resistor, Carbon Film, 1/4W, 5%
R 330	4-00022-401	1.0M	Resistor, Carbon Film, 1/4W, 5%
R 331	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 332	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 333	4-00048-401	2.2K	Resistor, Carbon Film, 1/4W, 5%
R 334	4-00077-401	390K	Resistor, Carbon Film, 1/4W, 5%
SW1	2-00018-210	1P12T	Switch, Rotary, PCB Mounted
SW2	2-00019-210	2P12T	Switch, Rotary, PCB Mounted
SW3	2-00019-210	2P12T	Switch, Rotary, PCB Mounted
SW4	2-00018-210	1P12T	Switch, Rotary, PCB Mounted
SW5	2-00019-210	2P12T	Switch, Rotary, PCB Mounted
SW6	2-00015-201	SPST	Switch, Momentary Push Button
SW7	2-00010-205	SPDT	Switch, ON-Off-On, Locking Toggle
SW8	2-00006-214	DPDT	Switch, Miniature Bat Toggle
SW9	2-00003-203	SPDT	Switch, ON-NONE-ON, Locking Toggle
U 1	3-00065-340	CA3102	Integrated Circuit (Thru-hole Pkg)
U 2	3-00087-340	LF347	Integrated Circuit (Thru-hole Pkg)
U 3	3-00313-340	74LS11	Integrated Circuit (Thru-hole Pkg)
U 4	3-00065-340	CA3102	Integrated Circuit (Thru-hole Pkg)
U 5	3-00065-340	CA3102	Integrated Circuit (Thru-hole Pkg)
U 6	3-00065-340	CA3102	Integrated Circuit (Thru-hole Pkg)
U 7	3-00087-340	LF347	Integrated Circuit (Thru-hole Pkg)
U 8	3-00052-340	74LS123	Integrated Circuit (Thru-hole Pkg)
U 9	3-00076-340	DG211	Integrated Circuit (Thru-hole Pkg)
U 10	3-00076-340	DG211	Integrated Circuit (Thru-hole Pkg)
U 11	3-00087-340	LF347	Integrated Circuit (Thru-hole Pkg)
U 12	3-00076-340	DG211	Integrated Circuit (Thru-hole Pkg)
U 13	3-00091-340	LF412	Integrated Circuit (Thru-hole Pkg)
U 14	3-00055-340	74LS74	Integrated Circuit (Thru-hole Pkg)
U 15	3-00052-340	74LS123	Integrated Circuit (Thru-hole Pkg)
U 16	3-00087-340	LF347	Integrated Circuit (Thru-hole Pkg)
U 17	3-00087-340	LF347	Integrated Circuit (Thru-hole Pkg)
U 18	3-00097-340	LM318	Integrated Circuit (Thru-hole Pkg)
U 19	3-00114-329	7815	Voltage Reg., TO-220 (TAB) Package
U 20	3-00112-329	7805	Voltage Reg., TO-220 (TAB) Package
U 21	3-00119-329	7905	Voltage Reg., TO-220 (TAB) Package
U 22	3-00120-329	7915	Voltage Reg., TO-220 (TAB) Package
Z 0	0-00002-008	2607	Dial
Z 0	0-00021-004	KLN500B1/4	Knobs
Z 0	0-00022-004	KLN500B1/8	Knobs

<u>Ref.</u>	<u>SRS Part#</u>	<u>Value</u>	<u>Description</u>
Z 0	0-00023-004	KN500B1/4	Knobs
Z 0	0-00025-005	3/8"	Lugs
Z 0	0-00027-055	11"	Wire, Other
Z 0	0-00030-060	NIM FP	Screw, Misc
Z 0	0-00031-006	200833-2	NIM (Nuclear Instrumentation Module)
Z 0	0-00032-006	202394-2	NIM (Nuclear Instrumentation Module)
Z 0	0-00034-006	202514-1	NIM (Nuclear Instrumentation Module)
Z 0	0-00036-006	203964-5	NIM (Nuclear Instrumentation Module)
Z 0	0-00037-006	204186-5	NIM (Nuclear Instrumentation Module)
Z 0	0-00040-006	66103-4	NIM (Nuclear Instrumentation Module)
Z 0	0-00043-011	4-40 KEP	Nut, Kep
Z 0	0-00051-056	RG174	Cable, Coax & Misc.
Z 0	0-00061-061	4-40X3/8B	Screw, Binding Head, Slotted
Z 0	0-00089-033	4"	Tie
Z 0	0-00100-040	1/4X1/16	Washer, Flat
Z 0	0-00103-040	3/8X3/32	Washer, Flat
Z 0	0-00108-054	1" #26	Wire #26 UL1061
Z 0	0-00109-050	1-1/2" #18	Wire #18 UL1007 Stripped 3/8x3/8 No Tin
Z 0	0-00110-053	1-1/2" #24	Wire #24 UL1007 Strip 1/4x1/4 Tin
Z 0	0-00113-053	10" #24	Wire #24 UL1007 Strip 1/4x1/4 Tin
Z 0	0-00115-053	11" #24	Wire #24 UL1007 Strip 1/4x1/4 Tin
Z 0	0-00117-053	12" #24	Wire #24 UL1007 Strip 1/4x1/4 Tin
Z 0	0-00118-053	14" #24	Wire #24 UL1007 Strip 1/4x1/4 Tin
Z 0	0-00119-053	15" #24	Wire #24 UL1007 Strip 1/4x1/4 Tin
Z 0	0-00123-053	21" #24	Wire #24 UL1007 Strip 1/4x1/4 Tin
Z 0	0-00124-053	22-1/2" #24	Wire #24 UL1007 Strip 1/4x1/4 Tin
Z 0	0-00126-053	3-1/2" #24	Wire #24 UL1007 Strip 1/4x1/4 Tin
Z 0	0-00128-053	4" #24	Wire #24 UL1007 Strip 1/4x1/4 Tin
Z 0	0-00129-053	5" #24	Wire #24 UL1007 Strip 1/4x1/4 Tin
Z 0	0-00132-053	6-1/2" #24	Wire #24 UL1007 Strip 1/4x1/4 Tin
Z 0	0-00133-052	7-1/2" #22	Wire #22 UL1007
Z 0	0-00134-053	7-1/4" #24	Wire #24 UL1007 Strip 1/4x1/4 Tin
Z 0	0-00136-053	8-1/2" #24	Wire #24 UL1007 Strip 1/4x1/4 Tin
Z 0	0-00165-003	TO-18	Insulators
Z 0	0-00187-021	4-40X1/4PP	Screw, Panhead Phillips
Z 0	0-00229-031	6-32 NIM FP	Standoff
Z 0	0-00230-061	4-40X1/4B	Screw, Binding Head, Slotted
Z 0	0-00289-053	14" #24	Wire #24 UL1007 Strip 1/4x1/4 Tin
Z 0	0-00407-032	SOLDR SLV RG174	Termination
Z 0	1-00003-120	BNC	Connector, BNC
Z 0	7-00015-710	SR250-6	Front Panel
Z 0	7-00043-711	SR250-7	Rear Panel
Z 0	7-00078-714	SR200-13	Extrusion
Z 0	7-00087-712	SR200-8	Side Panel
Z 0	7-00089-720	SR250-8	Fabricated Part
Z 0	7-00092-720	SR250-9	Fabricated Part
Z 0	7-00094-714	26-001	Extrusion
Z 0	9-00215-907	1/16" BLACK	Shrink Tubing
Z 0	9-00216-907	1/8" BLACK	Shrink Tubing

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<u>Ref.</u>	<u>SRS Part#</u>	<u>Value</u>	<u>Description</u>
Z 0	9-00267-917	GENERIC	Product Labels

**Model SR255 Parts List**

<b>Ref.</b>	<b>SRS Part#</b>	<b>Value</b>	<b>Description</b>
C 101	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 102	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 103	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 104	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 105	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 106	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 107	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 108	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 109	5-00023-529	.1U	Cap, Monolithic Ceramic, 50V, 20%, Z5U
C 110	5-00023-529	.1U	Cap, Monolithic Ceramic, 50V, 20%, Z5U
C 111	5-00003-501	10P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 112	5-00003-501	10P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 113	5-00083-516	200P	Capacitor, Silver Mica, 500V, 5%,
C 114	5-00062-513	.0022U	Capacitor, Mylar/Poly, 50V, 5%, Rad
C 115	5-00066-513	.022U	Capacitor, Mylar/Poly, 50V, 5%, Rad
C 116	5-00192-542	22U MIN	Cap, Mini Electrolytic, 50V, 20% Radial
C 117	5-00044-509	47U	Capacitor, Electrolytic, 50V, 20%, Rad
C 118	5-00192-542	22U MIN	Cap, Mini Electrolytic, 50V, 20% Radial
C 119	5-00192-542	22U MIN	Cap, Mini Electrolytic, 50V, 20% Radial
C 120	5-00011-501	27P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 201	5-00023-529	.1U	Cap, Monolithic Ceramic, 50V, 20%, Z5U
C 202	5-00022-501	.001U	Capacitor, Ceramic Disc, 50V, 10%, SL
C 203	5-00022-501	.001U	Capacitor, Ceramic Disc, 50V, 10%, SL
C 204	5-00025-504	100P	Capacitor, Chip (SMT0805), 50V, 10%, NPO
C 205	5-00025-504	100P	Capacitor, Chip (SMT0805), 50V, 10%, NPO
C 206	5-00026-504	22P	Capacitor, Chip (SMT0805), 50V, 10%, NPO
C 207	5-00026-504	22P	Capacitor, Chip (SMT0805), 50V, 10%, NPO
C 208	5-00038-509	10U	Capacitor, Electrolytic, 50V, 20%, Rad
C 209	5-00038-509	10U	Capacitor, Electrolytic, 50V, 20%, Rad
C 210	5-00089-516	47P	Capacitor, Silver Mica, 500V, 5%,
C 211	5-00089-516	47P	Capacitor, Silver Mica, 500V, 5%,
C 212	5-00092-523	1P	Capacitor, Silver Mica, Miniature
C 213	5-00107-530	1.8-6P	Capacitor, Variable, Misc.
C 214	5-00106-530	9.0-50P	Capacitor, Variable, Misc.
C 215	5-00077-516	100P	Capacitor, Silver Mica, 500V, 5%,
C 216	5-00003-501	10P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 217	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 218	5-00017-501	47P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 301	5-00010-501	270P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 302	5-00010-501	270P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 303	5-00022-501	.001U	Capacitor, Ceramic Disc, 50V, 10%, SL
C 304	5-00016-501	470P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 305	5-00003-501	10P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 306	5-00108-519	.0047U	Capacitor, Polystyrene, 50V, 5%, Rad
C 307	5-00022-501	.001U	Capacitor, Ceramic Disc, 50V, 10%, SL
C 308	5-00077-516	100P	Capacitor, Silver Mica, 500V, 5%,
C 309	5-00016-501	470P	Capacitor, Ceramic Disc, 50V, 10%, SL

<u>Ref.</u>	<u>SRS Part#</u>	<u>Value</u>	<u>Description</u>
C 310	5-00022-501	.001U	Capacitor, Ceramic Disc, 50V, 10%, SL
C 311	5-00010-501	270P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 401	5-00022-501	.001U	Capacitor, Ceramic Disc, 50V, 10%, SL
C 402	5-00002-501	100P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 403	5-00022-501	.001U	Capacitor, Ceramic Disc, 50V, 10%, SL
C 404	5-00023-529	.1U	Cap, Monolithic Ceramic, 50V, 20%, Z5U
C 405	5-00008-501	22P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 406	5-00008-501	22P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 407	5-00065-513	.01U	Capacitor, Mylar/Poly, 50V, 5%, Rad
C 408	5-00007-501	220P	Capacitor, Ceramic Disc, 50V, 10%, SL
C 408	5-00010-501	270P	Capacitor, Ceramic Disc, 50V, 10%, SL
D 101	3-00004-301	1N4148	Diode
D 102	3-00004-301	1N4148	Diode
D 201	3-00014-308	MMD835	Diode, Step Recovery
D 202	3-00205-302	MX3601	Diode, Dual Schottky
D 301	3-00004-301	1N4148	Diode
D 302	3-00004-301	1N4148	Diode
D 303	3-00004-301	1N4148	Diode
D 304	3-00004-301	1N4148	Diode
D 401	3-00010-303	GREEN	LED, T1 Package
D 402	3-00010-303	GREEN	LED, T1 Package
D 403	3-00010-303	GREEN	LED, T1 Package
D 404	3-00010-303	GREEN	LED, T1 Package
D 405	3-00010-303	GREEN	LED, T1 Package
D 406	3-00011-303	RED	LED, T1 Package
J 401	1-00005-160	15 PIN D	Connector, D-Sub, Right Angle PC, Female
P 101	4-00005-440	2.0K	Trim Pot, Single Turn, In-Line Leads
P 102	4-00004-440	10K	Trim Pot, Single Turn, In-Line Leads
P 301A	4-00914-452	10K	Pot, Multi Turn Trim, Mini
P 301B	4-00914-452	10K	Pot, Multi Turn Trim, Mini
P 301C	4-00914-452	10K	Pot, Multi Turn Trim, Mini
P 301D	4-00914-452	10K	Pot, Multi Turn Trim, Mini
P 302A	4-00914-452	10K	Pot, Multi Turn Trim, Mini
P 302B	4-00914-452	10K	Pot, Multi Turn Trim, Mini
P 302C	4-00914-452	10K	Pot, Multi Turn Trim, Mini
P 302D	4-00914-452	10K	Pot, Multi Turn Trim, Mini
P 401	4-00004-440	10K	Trim Pot, Single Turn, In-Line Leads
PC1	7-00032-701	SR255	Printed Circuit Board
PC2	7-00033-701	SR255DUR	Printed Circuit Board
Q 101	3-00028-325	2N5771	Transistor, TO-92 Package
Q 102	3-00028-325	2N5771	Transistor, TO-92 Package
Q 103	3-00028-325	2N5771	Transistor, TO-92 Package
Q 104	3-00028-325	2N5771	Transistor, TO-92 Package
Q 105	3-00028-325	2N5771	Transistor, TO-92 Package
Q 201	3-00019-324	MRF914	Transistor, TO-72 Package
Q 202	3-00015-322	2N5583	Transistor, TO-39 Package
Q 301	3-00024-325	2N5086	Transistor, TO-92 Package
Q 302	3-00024-325	2N5086	Transistor, TO-92 Package
Q 303	3-00024-325	2N5086	Transistor, TO-92 Package

<u>Ref.</u>	<u>SRS Part#</u>	<u>Value</u>	<u>Description</u>
Q 304	3-00024-325	2N5086	Transistor, TO-92 Package
Q 305	3-00025-325	2N5088	Transistor, TO-92 Package
Q 306	3-00025-325	2N5088	Transistor, TO-92 Package
Q 307	3-00025-325	2N5088	Transistor, TO-92 Package
R 101	4-00086-401	51	Resistor, Carbon Film, 1/4W, 5%
R 102	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 103	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 104	4-00031-401	100	Resistor, Carbon Film, 1/4W, 5%
R 105	4-00021-401	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 106	4-00021-401	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 107	4-00031-401	100	Resistor, Carbon Film, 1/4W, 5%
R 108	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 109	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 110	4-00050-401	2.4K	Resistor, Carbon Film, 1/4W, 5%
R 111	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 112	4-00027-401	1.5K	Resistor, Carbon Film, 1/4W, 5%
R 113	4-00076-401	390	Resistor, Carbon Film, 1/4W, 5%
R 114	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 115	4-00089-401	56	Resistor, Carbon Film, 1/4W, 5%
R 116	4-00090-401	560	Resistor, Carbon Film, 1/4W, 5%
R 117	4-00089-401	56	Resistor, Carbon Film, 1/4W, 5%
R 118	4-00089-401	56	Resistor, Carbon Film, 1/4W, 5%
R 119	4-00076-401	390	Resistor, Carbon Film, 1/4W, 5%
R 120	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 121	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 122	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 123	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 124	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 125	4-00208-407	825	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 126	4-00089-401	56	Resistor, Carbon Film, 1/4W, 5%
R 127	4-00089-401	56	Resistor, Carbon Film, 1/4W, 5%
R 128	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 129	4-00076-401	390	Resistor, Carbon Film, 1/4W, 5%
R 130	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 131	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 132	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 133	4-00031-401	100	Resistor, Carbon Film, 1/4W, 5%
R 134	4-00031-401	100	Resistor, Carbon Film, 1/4W, 5%
R 135	4-00031-401	100	Resistor, Carbon Film, 1/4W, 5%
R 136	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 137	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 138	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 139	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 140	4-00103-401	820	Resistor, Carbon Film, 1/4W, 5%
R 141	4-00210-407	9.09K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 142	4-00138-407	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 143	4-00153-407	15.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 144	4-00138-407	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 145	4-00138-407	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM

<u>Ref.</u>	<u>SRS Part#</u>	<u>Value</u>	<u>Description</u>
R 146	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 147	4-00055-401	20K	Resistor, Carbon Film, 1/4W, 5%
R 148	4-00055-401	20K	Resistor, Carbon Film, 1/4W, 5%
R 150	4-00087-401	510	Resistor, Carbon Film, 1/4W, 5%
R 151	4-00030-401	10	Resistor, Carbon Film, 1/4W, 5%
R 152	4-00030-401	10	Resistor, Carbon Film, 1/4W, 5%
R 153	4-00047-401	2.2	Resistor, Carbon Film, 1/4W, 5%
R 154	4-00047-401	2.2	Resistor, Carbon Film, 1/4W, 5%
R 155	4-00030-401	10	Resistor, Carbon Film, 1/4W, 5%
R 156	4-00030-401	10	Resistor, Carbon Film, 1/4W, 5%
R 157	4-00030-401	10	Resistor, Carbon Film, 1/4W, 5%
R 158	4-00030-401	10	Resistor, Carbon Film, 1/4W, 5%
R 201	4-00041-401	150	Resistor, Carbon Film, 1/4W, 5%
R 202	4-00062-401	270	Resistor, Carbon Film, 1/4W, 5%
R 203	4-00079-401	4.7K	Resistor, Carbon Film, 1/4W, 5%
R 204	4-00079-401	4.7K	Resistor, Carbon Film, 1/4W, 5%
R 205	4-00062-401	270	Resistor, Carbon Film, 1/4W, 5%
R 206	4-00062-401	270	Resistor, Carbon Film, 1/4W, 5%
R 207	4-00122-405	47	Resistor, Carbon Film, 1/8W, 5%
R 208	4-01443-461	33	Thick Film, 5%, 200 ppm, Chip Resistor
R 209	4-01448-461	51	Thick Film, 5%, 200 ppm, Chip Resistor
R 210	4-00032-401	100K	Resistor, Carbon Film, 1/4W, 5%
R 211	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 212	4-00032-401	100K	Resistor, Carbon Film, 1/4W, 5%
R 213	4-00116-405	1.0K	Resistor, Carbon Film, 1/8W, 5%
R 214	4-00116-405	1.0K	Resistor, Carbon Film, 1/8W, 5%
R 215	4-00032-401	100K	Resistor, Carbon Film, 1/4W, 5%
R 216	4-00032-401	100K	Resistor, Carbon Film, 1/4W, 5%
R 217	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 218	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 219	4-00037-401	11K	Resistor, Carbon Film, 1/4W, 5%
R 220	4-00081-401	470	Resistor, Carbon Film, 1/4W, 5%
R 221	4-00031-401	100	Resistor, Carbon Film, 1/4W, 5%
R 222	4-00021-401	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 223	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 224	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 225	4-00021-401	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 226	6-00000-600	DELETED	Misc. Components
R 227	4-00021-401	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 228	4-00057-401	220	Resistor, Carbon Film, 1/4W, 5%
R 229	4-00071-401	33	Resistor, Carbon Film, 1/4W, 5%
R 230	4-00117-405	10	Resistor, Carbon Film, 1/8W, 5%
R 231	4-00117-405	10	Resistor, Carbon Film, 1/8W, 5%
R 232	4-00119-405	150	Resistor, Carbon Film, 1/8W, 5%
R 233	4-01435-461	15	Thick Film, 5%, 200 ppm, Chip Resistor
R 234	4-01435-461	15	Thick Film, 5%, 200 ppm, Chip Resistor
R 235	4-01435-461	15	Thick Film, 5%, 200 ppm, Chip Resistor
R 236	4-01435-461	15	Thick Film, 5%, 200 ppm, Chip Resistor
R 301	4-00043-401	180	Resistor, Carbon Film, 1/4W, 5%



<u>Ref.</u>	<u>SRS Part#</u>	<u>Value</u>	<u>Description</u>
R 302	4-00057-401	220	Resistor, Carbon Film, 1/4W, 5%
R 303	4-00057-401	220	Resistor, Carbon Film, 1/4W, 5%
R 305	4-00048-401	2.2K	Resistor, Carbon Film, 1/4W, 5%
R 306	4-00048-401	2.2K	Resistor, Carbon Film, 1/4W, 5%
R 307	4-00048-401	2.2K	Resistor, Carbon Film, 1/4W, 5%
R 308	4-00048-401	2.2K	Resistor, Carbon Film, 1/4W, 5%
R 309	4-00072-401	330	Resistor, Carbon Film, 1/4W, 5%
R 310	4-00072-401	330	Resistor, Carbon Film, 1/4W, 5%
R 311	4-00057-401	220	Resistor, Carbon Film, 1/4W, 5%
R 312	4-00057-401	220	Resistor, Carbon Film, 1/4W, 5%
R 313	4-00021-401	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 314	4-00021-401	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 315	4-00021-401	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 316	4-00021-401	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 317	4-00057-401	220	Resistor, Carbon Film, 1/4W, 5%
R 318	4-00057-401	220	Resistor, Carbon Film, 1/4W, 5%
R 319	4-00090-401	560	Resistor, Carbon Film, 1/4W, 5%
R 320	4-00072-401	330	Resistor, Carbon Film, 1/4W, 5%
R 321	4-00062-401	270	Resistor, Carbon Film, 1/4W, 5%
R 322	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 323	4-00078-401	39K	Resistor, Carbon Film, 1/4W, 5%
R 324	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 325	4-00084-401	5.1K	Resistor, Carbon Film, 1/4W, 5%
R 326	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 327	4-00048-401	2.2K	Resistor, Carbon Film, 1/4W, 5%
R 328	4-00079-401	4.7K	Resistor, Carbon Film, 1/4W, 5%
R 329	4-00021-401	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 330	4-00031-401	100	Resistor, Carbon Film, 1/4W, 5%
R 331	4-00032-401	100K	Resistor, Carbon Film, 1/4W, 5%
R 332	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 333	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 334	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 335	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 336	4-00094-401	6.8K	Resistor, Carbon Film, 1/4W, 5%
R 337	4-00072-401	330	Resistor, Carbon Film, 1/4W, 5%
R 338	4-00072-401	330	Resistor, Carbon Film, 1/4W, 5%
R 339	4-00094-401	6.8K	Resistor, Carbon Film, 1/4W, 5%
R 340	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 341	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
R 342	4-00031-401	100	Resistor, Carbon Film, 1/4W, 5%
R 401	4-00072-401	330	Resistor, Carbon Film, 1/4W, 5%
R 402	4-00072-401	330	Resistor, Carbon Film, 1/4W, 5%
R 403	4-00072-401	330	Resistor, Carbon Film, 1/4W, 5%
R 404	4-00072-401	330	Resistor, Carbon Film, 1/4W, 5%
R 405	4-00021-401	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 406	4-00039-401	120K	Resistor, Carbon Film, 1/4W, 5%
R 407	4-00138-407	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 408	4-00188-407	4.99K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 409	4-00079-401	4.7K	Resistor, Carbon Film, 1/4W, 5%

<u>Ref.</u>	<u>SRS Part#</u>	<u>Value</u>	<u>Description</u>
R 410	4-00058-401	220K	Resistor, Carbon Film, 1/4W, 5%
R 411	4-00057-401	220	Resistor, Carbon Film, 1/4W, 5%
R 412	4-00130-407	1.00K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 413	4-00152-407	140	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 414	4-00192-407	49.9K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 415	4-00081-401	470	Resistor, Carbon Film, 1/4W, 5%
R 416	4-00192-407	49.9K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 417	4-00032-401	100K	Resistor, Carbon Film, 1/4W, 5%
R 418	4-00072-401	330	Resistor, Carbon Film, 1/4W, 5%
R 419	4-00081-401	470	Resistor, Carbon Film, 1/4W, 5%
R 420	4-00021-401	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 421	4-00032-401	100K	Resistor, Carbon Film, 1/4W, 5%
R 422	4-00086-401	51	Resistor, Carbon Film, 1/4W, 5%
R 423	4-00021-401	1.0K	Resistor, Carbon Film, 1/4W, 5%
RN401	4-00225-425	100KX9	Resistor Network SIP 1/4W 2% (Common)
SO1	1-00026-150	28 PIN 600 MIL	Socket, THRU-HOLE
SW101	2-00012-206	SPDT	Switch, On-Off-On, Toggle, Right Angle
SW102	2-00008-207	SPSTX4	Switch, DIP
SW201	2-00008-207	SPSTX4	Switch, DIP
SW301	2-00011-206	DPDT	Switch, On-Off-On, Toggle, Right Angle
SW401	2-00008-207	SPSTX4	Switch, DIP
SW402	2-00008-207	SPSTX4	Switch, DIP
T 1	6-00009-610	T1-1-X65	Transformer
U 101	3-00114-329	7815	Voltage Reg., TO-220 (TAB) Package
U 102	3-00112-329	7805	Voltage Reg., TO-220 (TAB) Package
U 103	3-00119-329	7905	Voltage Reg., TO-220 (TAB) Package
U 104	3-00120-329	7915	Voltage Reg., TO-220 (TAB) Package
U 105	3-00065-340	CA3102	Integrated Circuit (Thru-hole Pkg)
U 106	3-00065-340	CA3102	Integrated Circuit (Thru-hole Pkg)
U 107	3-00091-340	LF412	Integrated Circuit (Thru-hole Pkg)
U 201	3-00104-340	LM733	Integrated Circuit (Thru-hole Pkg)
U 301	3-00052-340	74LS123	Integrated Circuit (Thru-hole Pkg)
U 302	3-00097-340	LM318	Integrated Circuit (Thru-hole Pkg)
U 303	3-00076-340	DG211	Integrated Circuit (Thru-hole Pkg)
U 304	3-00087-340	LF347	Integrated Circuit (Thru-hole Pkg)
U 305	3-00094-340	LM311	Integrated Circuit (Thru-hole Pkg)
U 306	3-00073-340	CD4052	Integrated Circuit (Thru-hole Pkg)
U 401	3-00036-340	74HC00	Integrated Circuit (Thru-hole Pkg)
U 402	3-00049-340	74HC74	Integrated Circuit (Thru-hole Pkg)
U 403	3-00054-340	74LS21	Integrated Circuit (Thru-hole Pkg)
U 404	3-00060-340	AD7574	Integrated Circuit (Thru-hole Pkg)
U 405	3-00052-340	74LS123	Integrated Circuit (Thru-hole Pkg)
U 406	3-00305-342	27C64-255	EPROM/PROM, I.C.
U 407	3-00041-340	74HC174	Integrated Circuit (Thru-hole Pkg)
U 408	3-00044-340	74HC244	Integrated Circuit (Thru-hole Pkg)
U 409	3-00046-340	74HC374	Integrated Circuit (Thru-hole Pkg)
U 410	3-00092-340	LH0071	Integrated Circuit (Thru-hole Pkg)
U 411	3-00087-340	LF347	Integrated Circuit (Thru-hole Pkg)
U 412	3-00058-340	AD7524	Integrated Circuit (Thru-hole Pkg)

<u>Ref.</u>	<u>SRS Part#</u>	<u>Value</u>	<u>Description</u>
U 413	3-00036-340	74HC00	Integrated Circuit (Thru-hole Pkg)
U 414	3-00050-340	74HC85	Integrated Circuit (Thru-hole Pkg)
U 415	3-00049-340	74HC74	Integrated Circuit (Thru-hole Pkg)
Z 0	0-00025-005	3/8"	Lugs
Z 0	0-00030-060	NIM FP	Screw, Misc
Z 0	0-00031-006	200833-2	NIM (Nuclear Instrumentation Module)
Z 0	0-00032-006	202394-2	NIM (Nuclear Instrumentation Module)
Z 0	0-00034-006	202514-1	NIM (Nuclear Instrumentation Module)
Z 0	0-00036-006	203964-5	NIM (Nuclear Instrumentation Module)
Z 0	0-00037-006	204186-5	NIM (Nuclear Instrumentation Module)
Z 0	0-00040-006	66103-4	NIM (Nuclear Instrumentation Module)
Z 0	0-00043-011	4-40 KEP	Nut, Kep
Z 0	0-00044-012	4-40 KNURL	Nut, Knurl
Z 0	0-00048-011	6-32 KEP	Nut, Kep
Z 0	0-00061-061	4-40X3/8B	Screw, Binding Head, Slotted
Z 0	0-00079-031	4-40X3/16 M/F	Standoff
Z 0	0-00089-033	4"	Tie
Z 0	0-00099-040	#6 FLAT	Washer, Flat
Z 0	0-00110-053	1-1/2" #24	Wire #24 UL1007 Strip 1/4x1/4 Tin
Z 0	0-00111-053	1-3/4" #24B	Wire #24 UL1007 Strip 1/4x1/4 Tin
Z 0	0-00112-053	1-3/4" #24R	Wire #24 UL1007 Strip 1/4x1/4 Tin
Z 0	0-00165-003	TO-18	Insulators
Z 0	0-00187-021	4-40X1/4PP	Screw, Panhead Phillips
Z 0	0-00207-003	TO-5	Insulators
Z 0	0-00209-021	4-40X3/8PP	Screw, Panhead Phillips
Z 0	0-00210-020	4-40X5/16PF	Screw, Flathead Phillips
Z 0	0-00222-021	6-32X1/4PP	Screw, Panhead Phillips
Z 0	0-00229-031	6-32 NIM FP	Standoff
Z 0	0-00230-061	4-40X1/4B	Screw, Binding Head, Slotted
Z 0	0-00532-053	3-1/2 YEL NOTIN	Wire #24 UL1007 Strip 1/4x1/4 Tin
Z 0	0-00533-053	2-1/4 RED NOTIN	Wire #24 UL1007 Strip 1/4x1/4 Tin
Z 0	1-00003-120	BNC	Connector, BNC
Z 0	1-00018-111	UG-58A/U	Connector, N-type, Panel Mount
Z 0	1-00019-111	UG201A/U	Connector, N-type, Panel Mount
Z 0	7-00016-710	SR255	Front Panel
Z 0	7-00023-721	FAST BRACK	Machined Part
Z 0	7-00044-711	SR255	Rear Panel
Z 0	7-00049-712	SR255-8	Side Panel
Z 0	7-00078-714	SR200-13	Extrusion
Z 0	7-00087-712	SR200-8	Side Panel
Z 0	7-00088-720	SR200-12	Fabricated Part
Z 0	7-00091-720	25-001	Fabricated Part
Z 0	7-00094-714	26-001	Extrusion
Z 0	9-00267-917	GENERIC	Product Labels

## Model SR275 Parts List

<u>Ref.</u>	<u>SRS Part#</u>	<u>Value</u>	<u>Description</u>
C 1	5-00069-513	.1U	Capacitor, Mylar/Poly, 50V, 5%, Rad
C 2	5-00075-515	.22U	Capacitor, Mylar/Poly, 50V, 10%, Rad
C 3	5-00075-515	.22U	Capacitor, Mylar/Poly, 50V, 10%, Rad
C 4	5-00077-516	100P	Capacitor, Silver Mica, 500V, 5%,
C 5	5-00065-513	.01U	Capacitor, Mylar/Poly, 50V, 5%, Rad
C 6	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 7	5-00096-517	.33U	Capacitor, Tantalum, 35V, 20%, Rad
C 8	5-00096-517	.33U	Capacitor, Tantalum, 35V, 20%, Rad
C 9	5-00096-517	.33U	Capacitor, Tantalum, 35V, 20%, Rad
C 10	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C 11	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C 12	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C 13	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
M 1	8-00002-801	#DIV/0!	Analog Meter
P 1	4-00017-445	20K	Pot, Multi-Turn, Side Adjust
PC1	7-00034-701	SR275	Printed Circuit Board
R 1	4-00055-401	20K	Resistor, Carbon Film, 1/4W, 5%
R 2	4-00082-401	470K	Resistor, Carbon Film, 1/4W, 5%
R 3	4-00036-401	110K	Resistor, Carbon Film, 1/4W, 5%
R 4	4-00216-407	909K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 5	4-00142-407	100K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 6	4-00032-401	100K	Resistor, Carbon Film, 1/4W, 5%
R 7	4-00057-401	220	Resistor, Carbon Film, 1/4W, 5%
R 8	4-00057-401	220	Resistor, Carbon Film, 1/4W, 5%
R 9	4-00068-401	300	Resistor, Carbon Film, 1/4W, 5%
R 10	4-00205-407	750K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 11	4-00170-407	249K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 12	4-00138-407	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 13	4-00148-407	12.1K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 14	4-00138-407	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 15	4-00138-407	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 16	4-00138-407	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 17	4-00138-407	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 18	4-00021-401	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 20	4-00032-401	100K	Resistor, Carbon Film, 1/4W, 5%
R 21	4-00032-401	100K	Resistor, Carbon Film, 1/4W, 5%
R 22	4-00022-401	1.0M	Resistor, Carbon Film, 1/4W, 5%
R 23	4-00055-401	20K	Resistor, Carbon Film, 1/4W, 5%
R 24	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 25	4-00029-401	1.8K	Resistor, Carbon Film, 1/4W, 5%
R 26	4-00021-401	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 27	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
SO1	1-00027-150	40 PIN 600 MIL	Socket, THRU-HOLE
SO2	1-00024-150	20 PIN 300 MIL	Socket, THRU-HOLE
SO3	1-00024-150	20 PIN 300 MIL	Socket, THRU-HOLE
SO6	1-00021-150	14 PIN 300 MIL	Socket, THRU-HOLE
SO7	1-00021-150	14 PIN 300 MIL	Socket, THRU-HOLE

<u>Ref.</u>	<u>SRS Part#</u>	<u>Value</u>	<u>Description</u>
SO8	1-00021-150	14 PIN 300 MIL	Socket, THRU-HOLE
SO9	1-00021-150	14 PIN 300 MIL	Socket, THRU-HOLE
SO10	1-00021-150	14 PIN 300 MIL	Socket, THRU-HOLE
SO11	1-00021-150	14 PIN 300 MIL	Socket, THRU-HOLE
SO12	1-00021-150	14 PIN 300 MIL	Socket, THRU-HOLE
SO13	1-00021-150	14 PIN 300 MIL	Socket, THRU-HOLE
SO14	1-00021-150	14 PIN 300 MIL	Socket, THRU-HOLE
SW1	2-00016-208	SPST	Switch, Momentary Push Button, NO
SW2	2-00005-214	3PDT	Switch, Miniature Bat Toggle
U 1	3-00083-340	ICL7117	Integrated Circuit (Thru-hole Pkg)
U 2	3-00103-340	LM3914	Integrated Circuit (Thru-hole Pkg)
U 3	3-00103-340	LM3914	Integrated Circuit (Thru-hole Pkg)
U 4	3-00087-340	LF347	Integrated Circuit (Thru-hole Pkg)
U 5	3-00107-340	MAN72	Integrated Circuit (Thru-hole Pkg)
U 6	3-00107-340	MAN72	Integrated Circuit (Thru-hole Pkg)
U 7	3-00107-340	MAN72	Integrated Circuit (Thru-hole Pkg)
U 8	3-00108-340	MAN73	Integrated Circuit (Thru-hole Pkg)
U 9	3-00080-340	HDSP-4830	Integrated Circuit (Thru-hole Pkg)
U 10	3-00080-340	HDSP-4830	Integrated Circuit (Thru-hole Pkg)
U 11	3-00112-329	7805	Voltage Reg., TO-220 (TAB) Package
U 12	3-00122-325	79L05	Transistor, TO-92 Package
U 13	3-00124-325	79L15	Transistor, TO-92 Package
U 14	3-00118-325	78L15	Transistor, TO-92 Package
Z 0	0-00025-005	3/8"	Lugs
Z 0	0-00030-060	NIM FP	Screw, Misc
Z 0	0-00031-006	200833-2	NIM (Nuclear Instrumentation Module)
Z 0	0-00032-006	202394-2	NIM (Nuclear Instrumentation Module)
Z 0	0-00034-006	202514-1	NIM (Nuclear Instrumentation Module)
Z 0	0-00035-006	202516-3	NIM (Nuclear Instrumentation Module)
Z 0	0-00036-006	203964-5	NIM (Nuclear Instrumentation Module)
Z 0	0-00038-006	66099-4	NIM (Nuclear Instrumentation Module)
Z 0	0-00042-010	4-40 HEX	Nut, Hex
Z 0	0-00043-011	4-40 KEP	Nut, Kep
Z 0	0-00048-011	6-32 KEP	Nut, Kep
Z 0	0-00061-061	4-40X3/8B	Screw, Binding Head, Slotted
Z 0	0-00064-027	6-20X5/8P	Screw, Sheet Metal
Z 0	0-00084-032	36154	Termination
Z 0	0-00089-033	4"	Tie
Z 0	0-00095-040	#4 FLAT	Washer, Flat
Z 0	0-00100-040	1/4X1/16	Washer, Flat
Z 0	0-00101-040	1/4X1/32	Washer, Flat
Z 0	0-00107-044	RED	Window
Z 0	0-00110-053	1-1/2" #24	Wire #24 UL1007 Strip 1/4x1/4 Tin
Z 0	0-00120-050	16" #18	Wire #18 UL1007 Stripped 3/8x3/8 No Tin
Z 0	0-00137-050	8-1/4" #18	Wire #18 UL1007 Stripped 3/8x3/8 No Tin
Z 0	0-00168-023	6-32X5/16R	Screw, Roundhead Phillips
Z 0	0-00187-021	4-40X1/4PP	Screw, Panhead Phillips
Z 0	0-00229-031	6-32 NIM FP	Standoff
Z 0	0-00230-061	4-40X1/4B	Screw, Binding Head, Slotted

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<u>Ref.</u>	<u>SRS Part#</u>	<u>Value</u>	<u>Description</u>
Z 0	0-00447-007	TO-220	Heat Sinks
Z 0	0-00533-053	2-1/4 RED NOTIN	Wire #24 UL1007 Strip 1/4x1/4 Tin
Z 0	1-00003-120	BNC	Connector, BNC
Z 0	7-00017-710	SR275	Front Panel
Z 0	7-00021-715	SR275	Bracket
Z 0	7-00078-714	SR200-13	Extrusion
Z 0	7-00086-711	SR275	Rear Panel
Z 0	7-00087-712	SR200-8	Side Panel
Z 0	7-00090-720	24-003	Fabricated Part
Z 0	7-00093-720	25-003	Fabricated Part
Z 0	7-00094-714	26-001	Extrusion
Z 0	7-00095-714	26-002	Extrusion
Z 0	9-00267-917	GENERIC	Product Labels

## SR280 Display PC board Parts List

<u>Ref.</u>	<u>SRS Part#</u>	<u>Value</u>	<u>Description</u>
C 1	5-00069-513	.1U	Capacitor, Mylar/Poly, 50V, 5%, Rad
C 2	5-00075-515	.22U	Capacitor, Mylar/Poly, 50V, 10%, Rad
C 3	5-00075-515	.22U	Capacitor, Mylar/Poly, 50V, 10%, Rad
C 4	5-00077-516	100P	Capacitor, Silver Mica, 500V, 5%,
C 5	5-00065-513	.01U	Capacitor, Mylar/Poly, 50V, 5%, Rad
C 6	5-00100-517	2.2U	Capacitor, Tantalum, 35V, 20%, Rad
C 7	5-00096-517	.33U	Capacitor, Tantalum, 35V, 20%, Rad
C 8	5-00096-517	.33U	Capacitor, Tantalum, 35V, 20%, Rad
C 9	5-00096-517	.33U	Capacitor, Tantalum, 35V, 20%, Rad
C 10	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C 11	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C 12	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C 13	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
C 101	5-00037-508	5800U	Capacitor, Electrolytic, 40V, +80/-20%
C 102	5-00037-508	5800U	Capacitor, Electrolytic, 40V, +80/-20%
C 103	5-00047-511	2400U	Capacitor, Electrolytic, 50V, +80/-20%
C 104	5-00047-511	2400U	Capacitor, Electrolytic, 50V, +80/-20%
F 101	6-00004-611	1A 3AG	Fuse
F 102	6-00005-611	2A 3AG	Fuse
M 1	8-00002-801	#DIV/0!	Analog Meter
P 1	4-00017-445	20K	Pot, Multi-Turn, Side Adjust
PC1	7-00034-701	SR275	Printed Circuit Board
R 1	4-00055-401	20K	Resistor, Carbon Film, 1/4W, 5%
R 2	4-00082-401	470K	Resistor, Carbon Film, 1/4W, 5%
R 3	4-00036-401	110K	Resistor, Carbon Film, 1/4W, 5%
R 4	4-00216-407	909K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 5	4-00142-407	100K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 6	4-00032-401	100K	Resistor, Carbon Film, 1/4W, 5%
R 7	4-00057-401	220	Resistor, Carbon Film, 1/4W, 5%
R 8	4-00057-401	220	Resistor, Carbon Film, 1/4W, 5%
R 9	4-00068-401	300	Resistor, Carbon Film, 1/4W, 5%
R 10	4-00205-407	750K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 11	4-00170-407	249K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 12	4-00138-407	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 13	4-00148-407	12.1K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 14	4-00138-407	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 15	4-00138-407	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 16	4-00138-407	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 17	4-00138-407	10.0K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 18	4-00021-401	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 19	4-00051-401	2.7K	Resistor, Carbon Film, 1/4W, 5%
R 20	4-00032-401	100K	Resistor, Carbon Film, 1/4W, 5%
R 21	4-00032-401	100K	Resistor, Carbon Film, 1/4W, 5%
R 22	4-00022-401	1.0M	Resistor, Carbon Film, 1/4W, 5%
R 23	4-00055-401	20K	Resistor, Carbon Film, 1/4W, 5%
R 24	4-00080-401	47	Resistor, Carbon Film, 1/4W, 5%
R 25	4-00029-401	1.8K	Resistor, Carbon Film, 1/4W, 5%

<u>Ref.</u>	<u>SRS Part#</u>	<u>Value</u>	<u>Description</u>
R 26	4-00021-401	1.0K	Resistor, Carbon Film, 1/4W, 5%
R 27	4-00034-401	10K	Resistor, Carbon Film, 1/4W, 5%
SO1	1-00027-150	40 PIN 600 MIL	Socket, THRU-HOLE
SO5	1-00021-150	14 PIN 300 MIL	Socket, THRU-HOLE
SO6	1-00021-150	14 PIN 300 MIL	Socket, THRU-HOLE
SO7	1-00021-150	14 PIN 300 MIL	Socket, THRU-HOLE
SO8	1-00021-150	14 PIN 300 MIL	Socket, THRU-HOLE
SO9	1-00024-150	20 PIN 300 MIL	Socket, THRU-HOLE
SO10	1-00024-150	20 PIN 300 MIL	Socket, THRU-HOLE
SO11	1-00021-150	14 PIN 300 MIL	Socket, THRU-HOLE
SO12	1-00021-150	14 PIN 300 MIL	Socket, THRU-HOLE
SO13	1-00021-150	14 PIN 300 MIL	Socket, THRU-HOLE
SO14	1-00021-150	14 PIN 300 MIL	Socket, THRU-HOLE
SW1	2-00016-208	SPST	Switch, Momentary Push Button, NO
SW1	2-00028-202	DPDT	Switch, ON-NONE-ON, Large Toggle
SW2	2-00005-214	3PDT	Switch, Miniature Bat Toggle
T 101	6-00008-610	SR280	Transformer
U 1	3-00083-340	ICL7117	Integrated Circuit (Thru-hole Pkg)
U 2	3-00103-340	LM3914	Integrated Circuit (Thru-hole Pkg)
U 3	3-00103-340	LM3914	Integrated Circuit (Thru-hole Pkg)
U 4	3-00087-340	LF347	Integrated Circuit (Thru-hole Pkg)
U 5	3-00107-340	MAN72	Integrated Circuit (Thru-hole Pkg)
U 6	3-00107-340	MAN72	Integrated Circuit (Thru-hole Pkg)
U 7	3-00107-340	MAN72	Integrated Circuit (Thru-hole Pkg)
U 8	3-00108-340	MAN73	Integrated Circuit (Thru-hole Pkg)
U 9	3-00080-340	HDSP-4830	Integrated Circuit (Thru-hole Pkg)
U 10	3-00080-340	HDSP-4830	Integrated Circuit (Thru-hole Pkg)
U 11	3-00112-329	7805	Voltage Reg., TO-220 (TAB) Package
U 12	3-00122-325	79L05	Transistor, TO-92 Package
U 13	3-00124-325	79L15	Transistor, TO-92 Package
U 14	3-00118-325	78L15	Transistor, TO-92 Package
U 101	3-00125-340	GBPC2502	Integrated Circuit (Thru-hole Pkg)
U 102	3-00125-340	GBPC2502	Integrated Circuit (Thru-hole Pkg)
Z 0	0-00007-002	AC RECPT	Power Entry Hardware
Z 0	0-00008-000	CAP BRACK	Hardware, Misc.
Z 0	0-00010-000	FUSEHOLDER	Hardware, Misc.
Z 0	0-00025-005	3/8"	Lugs
Z 0	0-00030-060	NIM FP	Screw, Misc
Z 0	0-00031-006	200833-2	NIM (Nuclear Instrumentation Module)
Z 0	0-00032-006	202394-2	NIM (Nuclear Instrumentation Module)
Z 0	0-00034-006	202514-1	NIM (Nuclear Instrumentation Module)
Z 0	0-00035-006	202516-3	NIM (Nuclear Instrumentation Module)
Z 0	0-00036-006	203964-5	NIM (Nuclear Instrumentation Module)
Z 0	0-00038-006	66099-4	NIM (Nuclear Instrumentation Module)
Z 0	0-00039-006	66101-4	NIM (Nuclear Instrumentation Module)
Z 0	0-00041-010	10-32 HEX	Nut, Hex
Z 0	0-00042-010	4-40 HEX	Nut, Hex
Z 0	0-00043-011	4-40 KEP	Nut, Kep
Z 0	0-00047-010	6-32 HEX	Nut, Hex



<u>Ref.</u>	<u>SRS Part#</u>	<u>Value</u>	<u>Description</u>
Z 0	0-00048-011	6-32 KEP	Nut, Kep
Z 0	0-00049-010	8-32 HEX	Nut, Hex
Z 0	0-00061-061	4-40X3/8B	Screw, Binding Head, Slotted
Z 0	0-00082-032	32054	Termination
Z 0	0-00084-032	36154	Termination
Z 0	0-00085-032	52422-1	Termination
Z 0	0-00087-032	640903-1	Termination
Z 0	0-00088-032	640905-1	Termination
Z 0	0-00089-033	4"	Tie
Z 0	0-00095-040	#4 FLAT	Washer, Flat
Z 0	0-00100-040	1/4X1/16	Washer, Flat
Z 0	0-00107-044	RED	Window
Z 0	0-00110-053	1-1/2" #24	Wire #24 UL1007 Strip 1/4x1/4 Tin
Z 0	0-00114-050	10-1/8"#18	Wire #18 UL1007 Stripped 3/8x3/8 No Tin
Z 0	0-00120-050	16" #18	Wire #18 UL1007 Stripped 3/8x3/8 No Tin
Z 0	0-00121-050	2-1/2" #18	Wire #18 UL1007 Stripped 3/8x3/8 No Tin
Z 0	0-00125-050	3" #18	Wire #18 UL1007 Stripped 3/8x3/8 No Tin
Z 0	0-00127-050	4" #18	Wire #18 UL1007 Stripped 3/8x3/8 No Tin
Z 0	0-00130-050	5-5/8" #18	Wire #18 UL1007 Stripped 3/8x3/8 No Tin
Z 0	0-00135-050	7-5/8" #18	Wire #18 UL1007 Stripped 3/8x3/8 No Tin
Z 0	0-00137-050	8-1/4" #18	Wire #18 UL1007 Stripped 3/8x3/8 No Tin
Z 0	0-00138-050	9" #18	Wire #18 UL1007 Stripped 3/8x3/8 No Tin
Z 0	0-00149-020	4-40X1/4PF	Screw, Flathead Phillips
Z 0	0-00168-023	6-32X5/16R	Screw, Roundhead Phillips
Z 0	0-00187-021	4-40X1/4PP	Screw, Panhead Phillips
Z 0	0-00208-020	4-40X3/8PF	Screw, Flathead Phillips
Z 0	0-00211-020	4-40X5/8PF	Screw, Flathead Phillips
Z 0	0-00215-023	6-32X5/8RP	Screw, Roundhead Phillips
Z 0	0-00216-020	8-32X3/4PF	Screw, Flathead Phillips
Z 0	0-00217-020	10-32X1PF	Screw, Flathead Phillips
Z 0	0-00218-020	10-32X3/8PF	Screw, Flathead Phillips
Z 0	0-00229-031	6-32 NIM FP	Standoff
Z 0	0-00230-061	4-40X1/4B	Screw, Binding Head, Slotted
Z 0	0-00260-023	10-32X1/4	Screw, Roundhead Phillips
Z 0	0-00262-050	16" #18	Wire #18 UL1007 Stripped 3/8x3/8 No Tin
Z 0	0-00447-007	TO-220	Heat Sinks
Z 0	0-00533-053	2-1/4 RED NOTIN	Wire #24 UL1007 Strip 1/4x1/4 Tin
Z 0	1-00003-120	BNC	Connector, BNC
Z 0	1-00053-172	USA	Line Cord
Z 0	7-00018-710	SR280-4	Front Panel
Z 0	7-00021-715	SR275	Bracket
Z 0	7-00024-720	SR280-1	Fabricated Part
Z 0	7-00045-711	SR280-120V	Rear Panel
Z 0	7-00046-711	SR280-220V	Rear Panel
Z 0	7-00078-714	SR200-13	Extrusion
Z 0	7-00087-712	SR200-8	Side Panel
Z 0	7-00090-720	24-003	Fabricated Part
Z 0	7-00093-720	25-003	Fabricated Part
Z 0	7-00094-714	26-001	Extrusion

<u>Ref.</u>	<u>SRS Part#</u>	<u>Value</u>	<u>Description</u>
Z 0	7-00095-714	26-002	Extrusion
Z 0	9-00267-917	GENERIC	Product Labels

**SR280 Regulator Strip Board Parts List**

<u>Ref.</u>	<u>SRS Part#</u>	<u>Value</u>	<u>Description</u>
C 1	5-00192-542	22U MIN	Cap, Mini Electrolytic, 50V, 20% Radial
C 2	5-00045-510	100U	Capacitor, Electrolytic, 50V, 20%, Ax
C 3	5-00045-510	100U	Capacitor, Electrolytic, 50V, 20%, Ax
C 4	5-00192-542	22U MIN	Cap, Mini Electrolytic, 50V, 20% Radial
C 5	5-00045-510	100U	Capacitor, Electrolytic, 50V, 20%, Ax
C 6	5-00045-510	100U	Capacitor, Electrolytic, 50V, 20%, Ax
C 7	5-00192-542	22U MIN	Cap, Mini Electrolytic, 50V, 20% Radial
C 8	5-00045-510	100U	Capacitor, Electrolytic, 50V, 20%, Ax
C 9	5-00045-510	100U	Capacitor, Electrolytic, 50V, 20%, Ax
C 10	5-00192-542	22U MIN	Cap, Mini Electrolytic, 50V, 20% Radial
C 11	5-00045-510	100U	Capacitor, Electrolytic, 50V, 20%, Ax
C 12	5-00045-510	100U	Capacitor, Electrolytic, 50V, 20%, Ax
C 13	5-00045-510	100U	Capacitor, Electrolytic, 50V, 20%, Ax
C 14	5-00023-529	.1U	Cap, Monolythic Ceramic, 50V, 20%, Z5U
D 1	3-00003-301	1N4007	Diode
D 2	3-00003-301	1N4007	Diode
D 3	3-00003-301	1N4007	Diode
D 4	3-00003-301	1N4007	Diode
D 5	3-00003-301	1N4007	Diode
D 6	3-00003-301	1N4007	Diode
D 7	3-00003-301	1N4007	Diode
P 1	4-00006-440	20	Trim Pot, Single Turn, In-Line Leads
P 2	4-00006-440	20	Trim Pot, Single Turn, In-Line Leads
P 3	4-00001-440	10	Trim Pot, Single Turn, In-Line Leads
P 4	4-00006-440	20	Trim Pot, Single Turn, In-Line Leads
PC1	7-00035-701	SR280	Printed Circuit Board
R 1	4-00165-407	200	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 2	4-00178-407	3.83K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 3	4-00165-407	200	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 4	4-00136-407	1.82K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 5	4-00141-407	100	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 6	4-00137-407	1.91K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 7	4-00165-407	200	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 8	4-00702-407	1.78K	Resistor, Metal Film, 1/8W, 1%, 50PPM
R 9	4-00021-401	1.0K	Resistor, Carbon Film, 1/4W, 5%
U 1	3-00095-331	LM317K	Voltage Regulator, TO-3 Metal Can
U 2	3-00102-331	LM350K	Voltage Regulator, TO-3 Metal Can
U 3	3-00099-331	LM337K	Voltage Regulator, TO-3 Metal Can
U 4	3-00101-331	LM333K	Voltage Regulator, TO-3 Metal Can
U 5	3-00105-340	LM741	Integrated Circuit (Thru-hole Pkg)
Z 0	0-00009-000	FOOT	Hardware, Misc.
Z 0	0-00015-031	6-32X1/4X1/4	Standoff
Z 0	0-00019-003	MICA	Insulators

<u>Ref.</u>	<u>SRS Part#</u>	<u>Value</u>	<u>Description</u>
Z 0	0-00020-003	PLASTIC	Insulators
Z 0	0-00031-006	200833-2	NIM (Nuclear Instrumentation Module)
Z 0	0-00033-006	202512-1	NIM (Nuclear Instrumentation Module)
Z 0	0-00035-006	202516-3	NIM (Nuclear Instrumentation Module)
Z 0	0-00036-006	203964-5	NIM (Nuclear Instrumentation Module)
Z 0	0-00038-006	66099-4	NIM (Nuclear Instrumentation Module)
Z 0	0-00039-006	66101-4	NIM (Nuclear Instrumentation Module)
Z 0	0-00048-011	6-32 KEP	Nut, Kep
Z 0	0-00089-033	4"	Tie
Z 0	0-00099-040	#6 FLAT	Washer, Flat
Z 0	0-00121-050	2-1/2" #18	Wire #18 UL1007 Stripped 3/8x3/8 No Tin
Z 0	0-00130-050	5-5/8" #18	Wire #18 UL1007 Stripped 3/8x3/8 No Tin
Z 0	0-00140-009	SHEET	Mylar Sheet
Z 0	0-00149-020	4-40X1/4PF	Screw, Flathead Phillips
Z 0	0-00167-023	6-32X1/2RP	Screw, Roundhead Phillips
Z 0	0-00181-020	6-32X1/4PF	Screw, Flathead Phillips
Z 0	0-00212-021	6-32X2PP	Screw, Panhead Phillips
Z 0	0-00213-023	6-32X3/4RP	Screw, Roundhead Phillips
Z 0	0-00215-023	6-32X5/8RP	Screw, Roundhead Phillips
Z 0	0-00238-026	6-32X1/4PF	Screw, Black, All Types
Z 0	0-00247-026	6-32X1/4 TRUSSP	Screw, Black, All Types
Z 0	0-00769-000	HANDLE NIM II	Hardware, Misc.
Z 0	0-00813-000	CARD GUIDE 8.5"	Hardware, Misc.
Z 0	0-00852-020	10-32X3/8 UNDER	Screw, Flathead Phillips
Z 0	1-00001-117	10 PIN RT.ANGLE	Header, Amp, MTA-156, Rt. Angle
Z 0	1-00002-113	10 PIN,18AWG/OR	Connector, Amp, MTA-156
Z 0	7-00022-720	SR280-3	Fabricated Part
Z 0	7-00025-714	SR280-2	Extrusion
Z 0	7-00743-720	BOXCAR-6	Fabricated Part
Z 0	7-00821-720	RT SIDE ASSY	Fabricated Part
Z 0	7-00822-720	LEFT SIDE ASSY	Fabricated Part
Z 0	7-00823-720	LARGE SCREEN	Fabricated Part
Z 0	7-00824-720	LOWER GUIDE	Fabricated Part
Z 0	7-00825-720	UPPER GUIDE	Fabricated Part
Z 0	9-00267-917	GENERIC	Product Labels

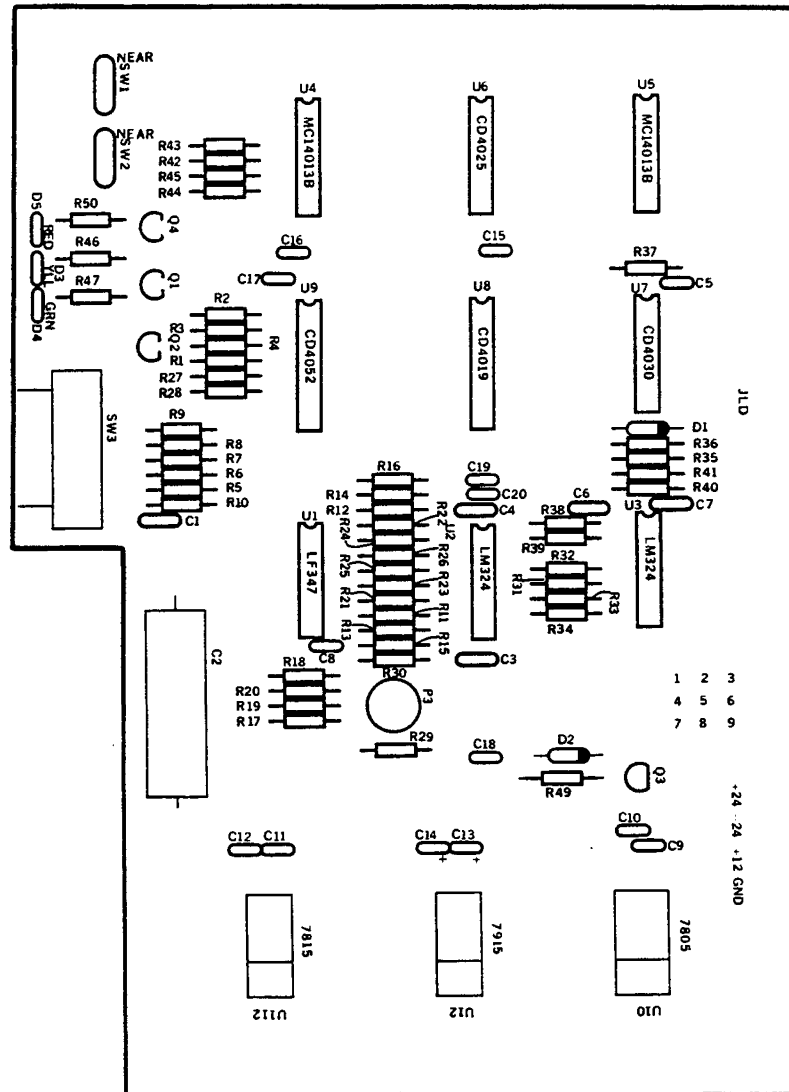


Figure 46 - SR200 Gate Scanner

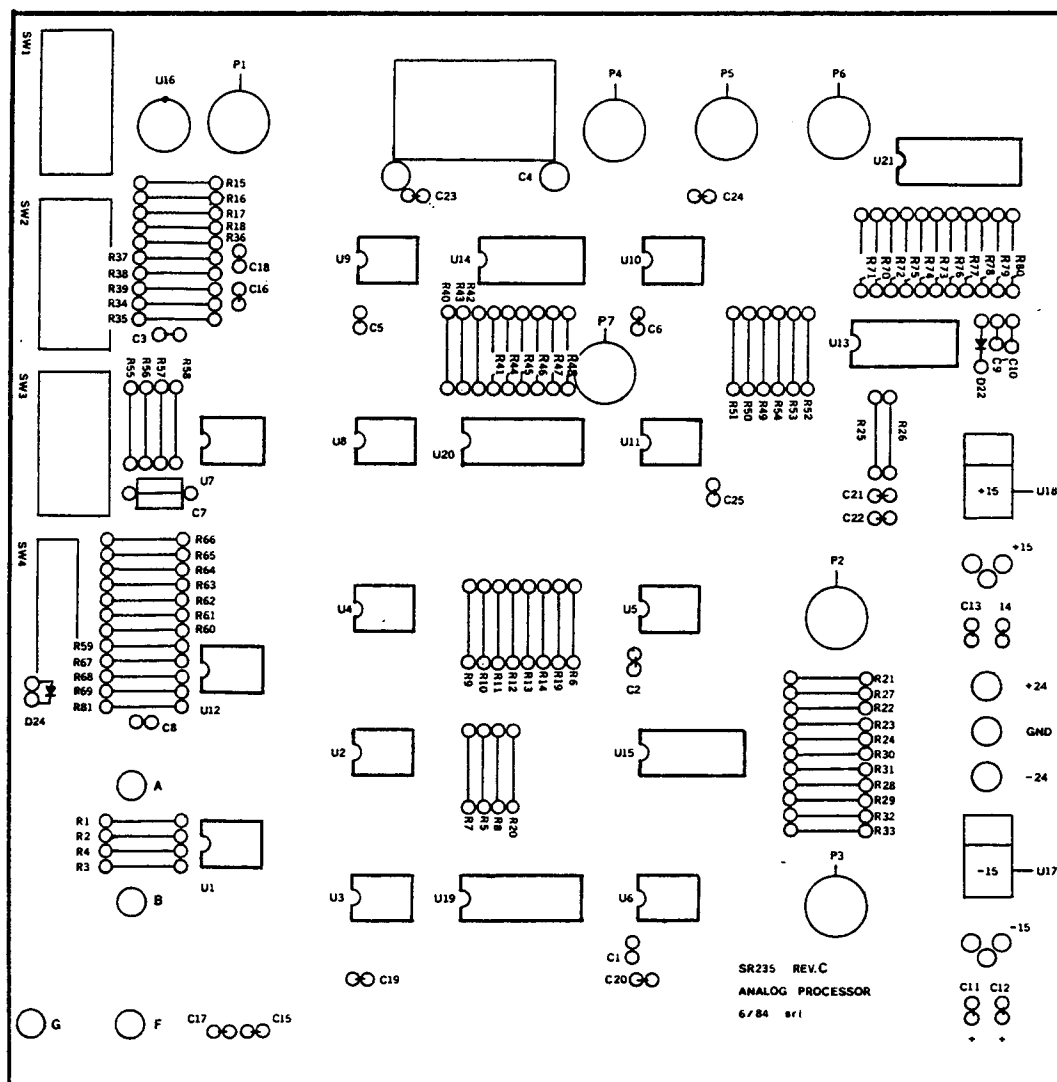


Figure 47 - SR235 Analog Processor

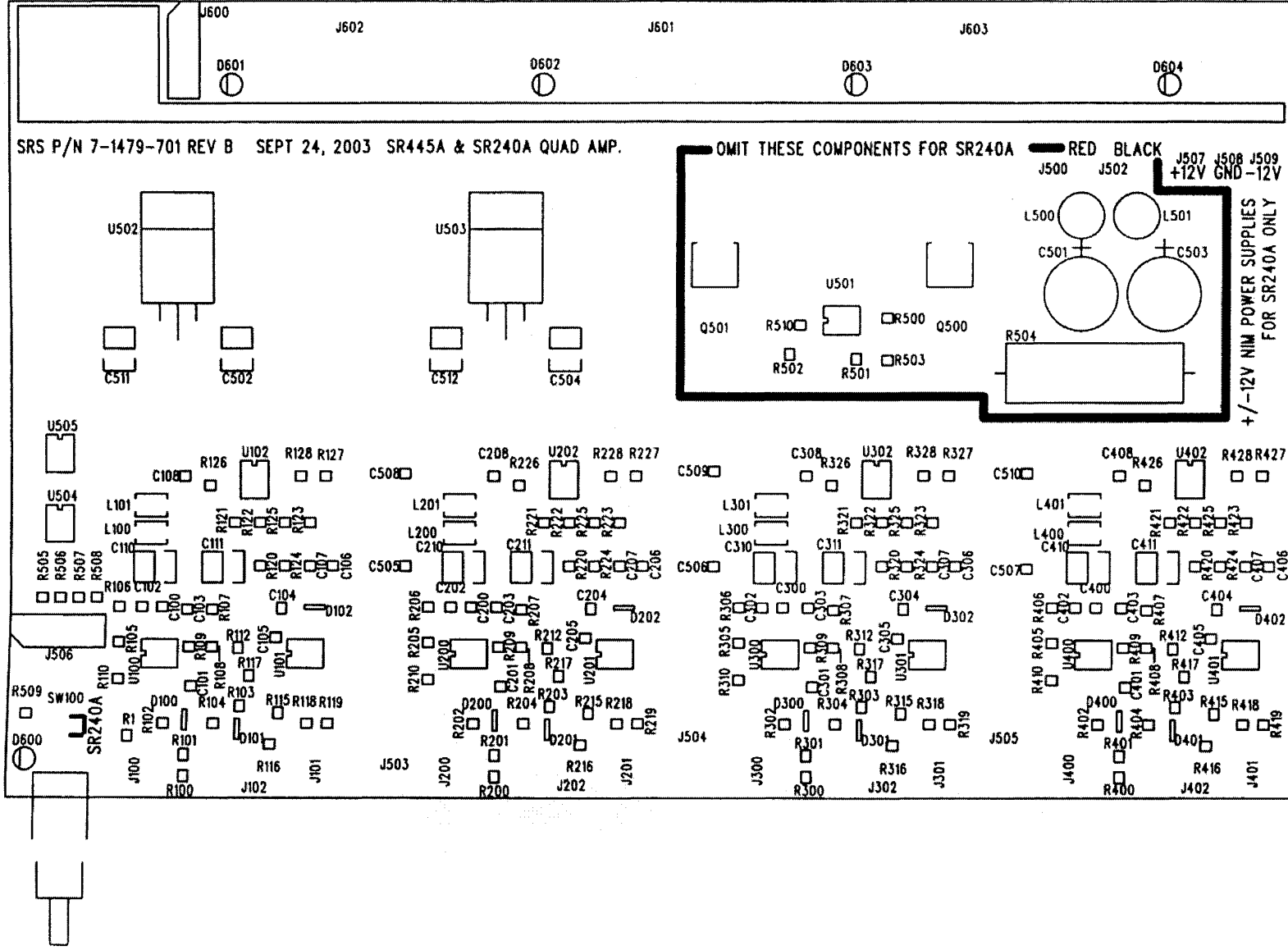


Figure 48 – SR240 Fast Preamp

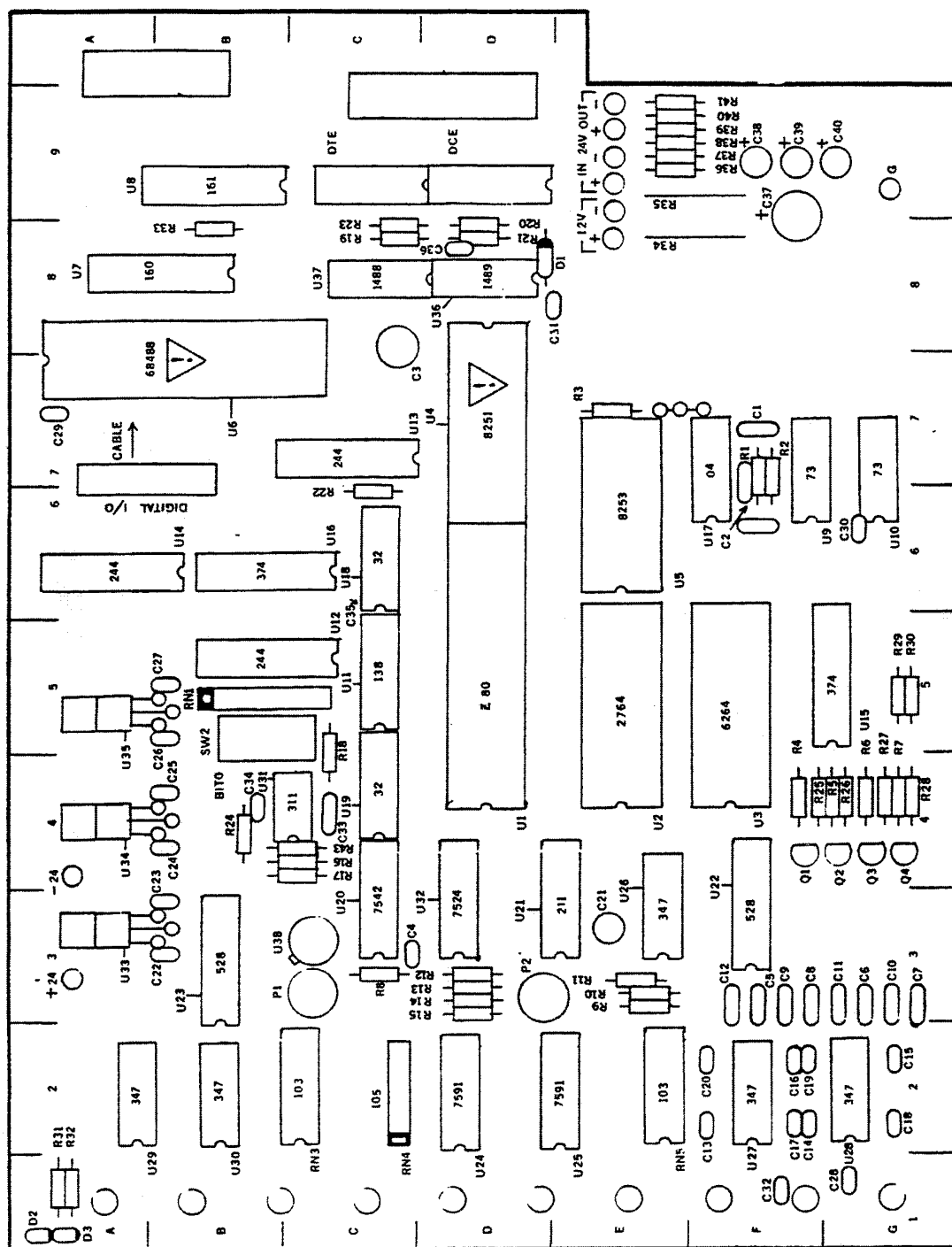


Figure 49 - SR245 Computer Interface

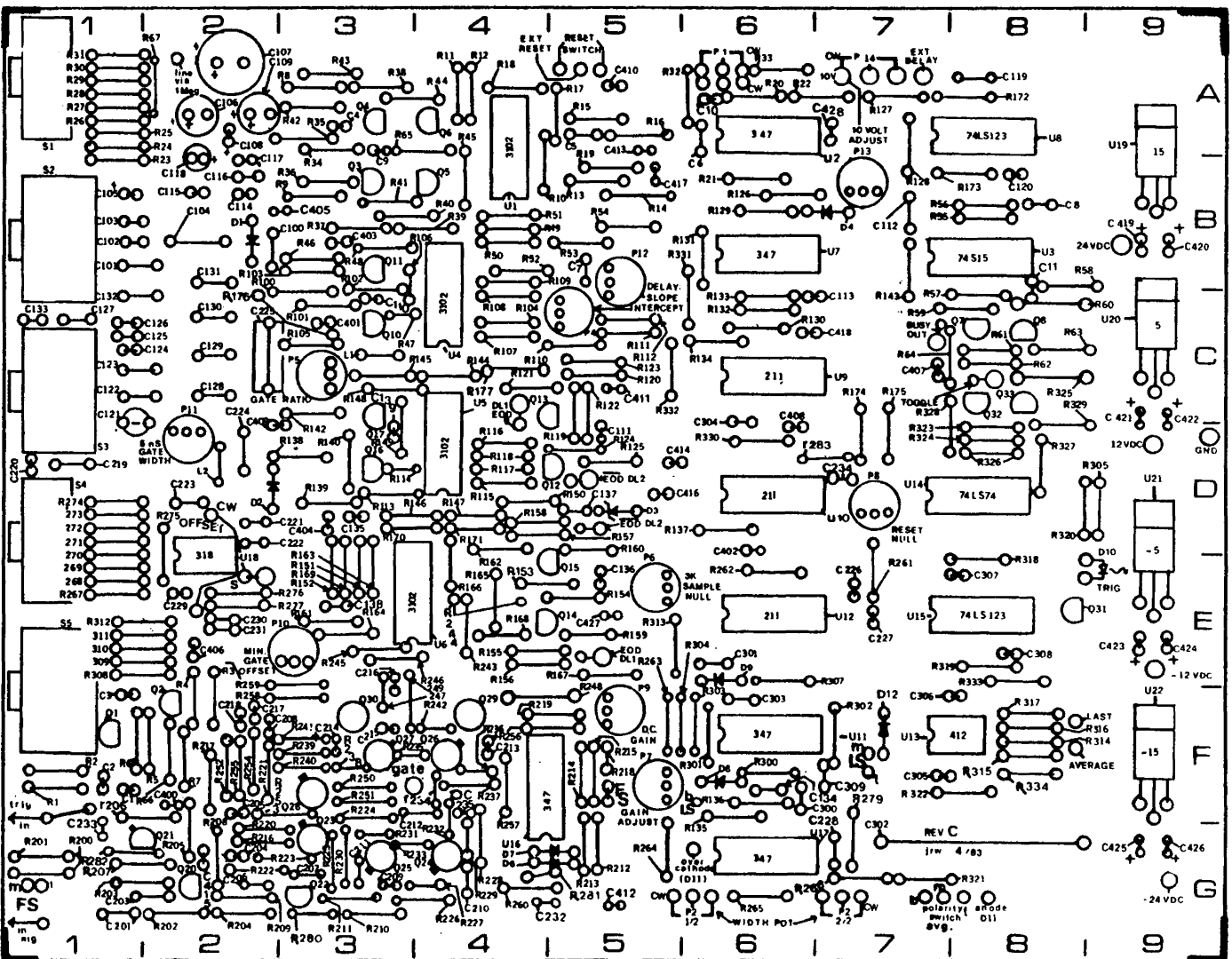


Figure 50 - SR250 Gated Integrator and Boxcar Averager



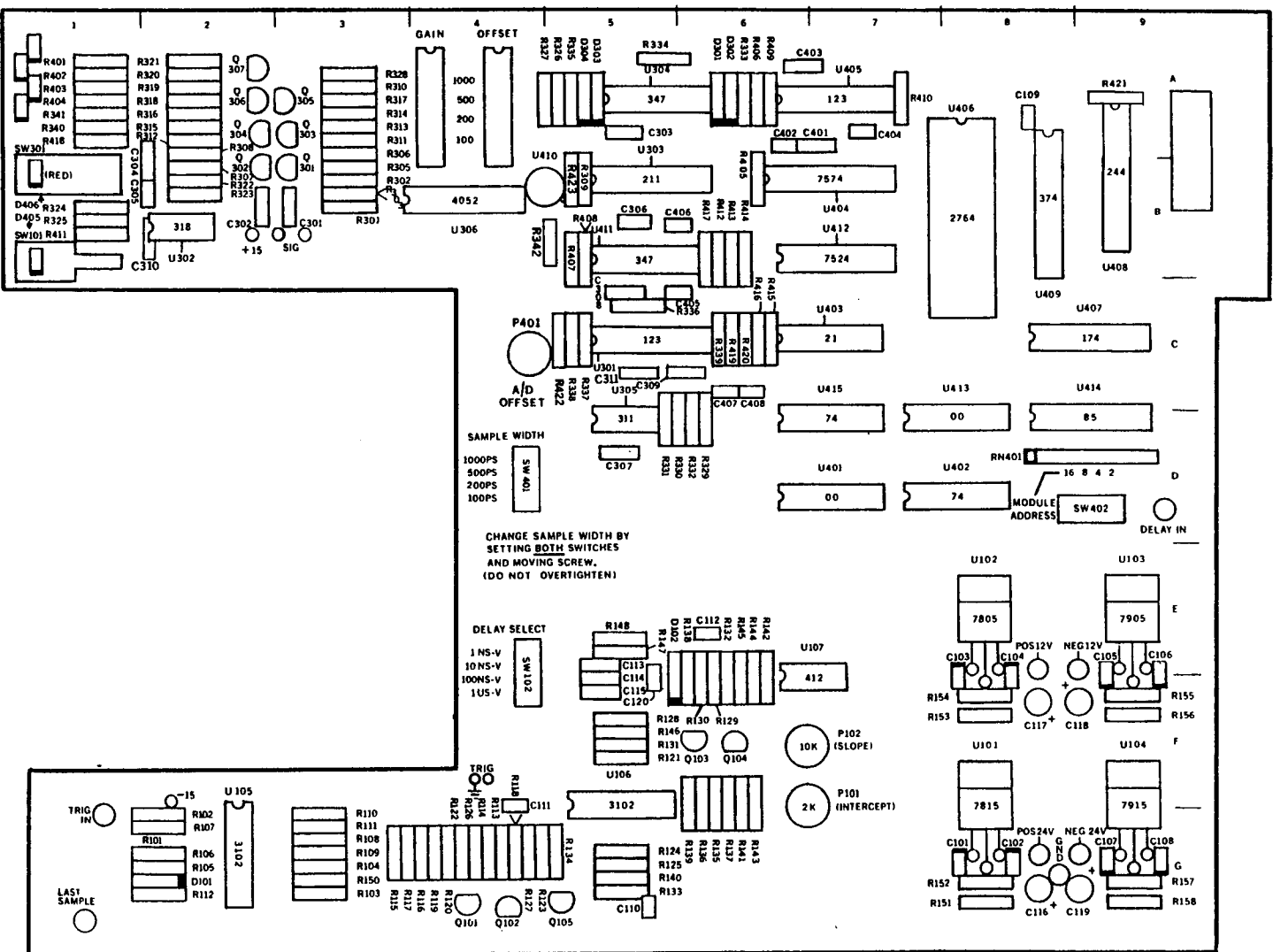


Figure 51 - SR255 Fast Sampler: Main Board

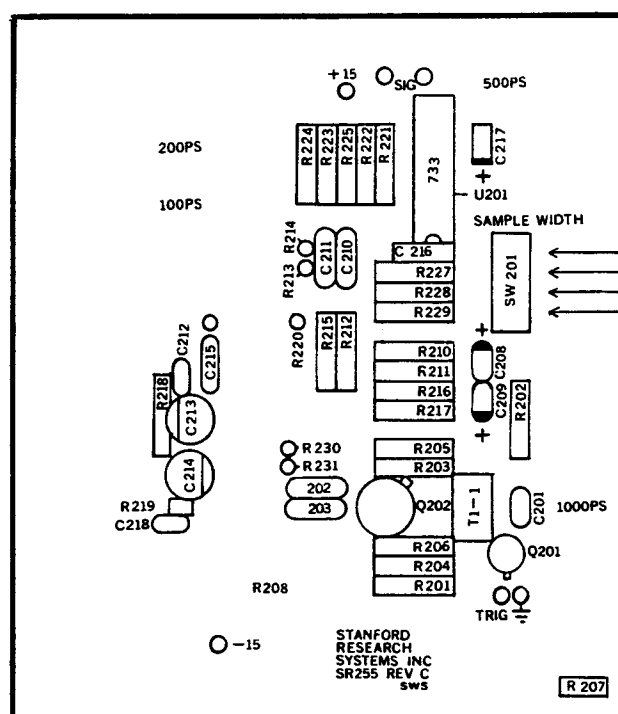


Figure 52 - SR255 Fast Sampler: Fast Board

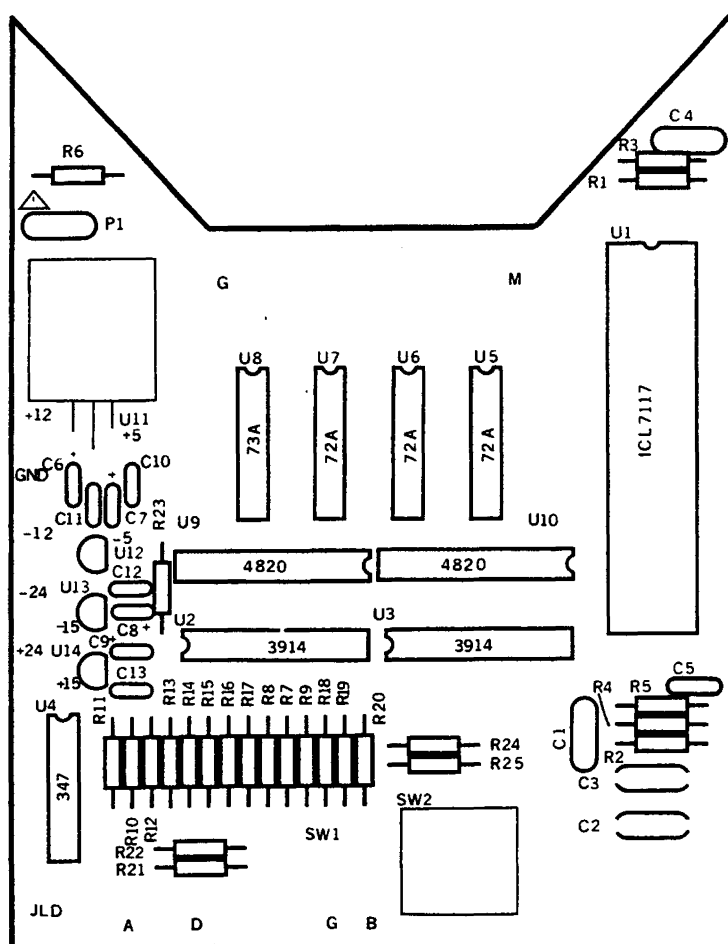


Figure 53 - Display PC

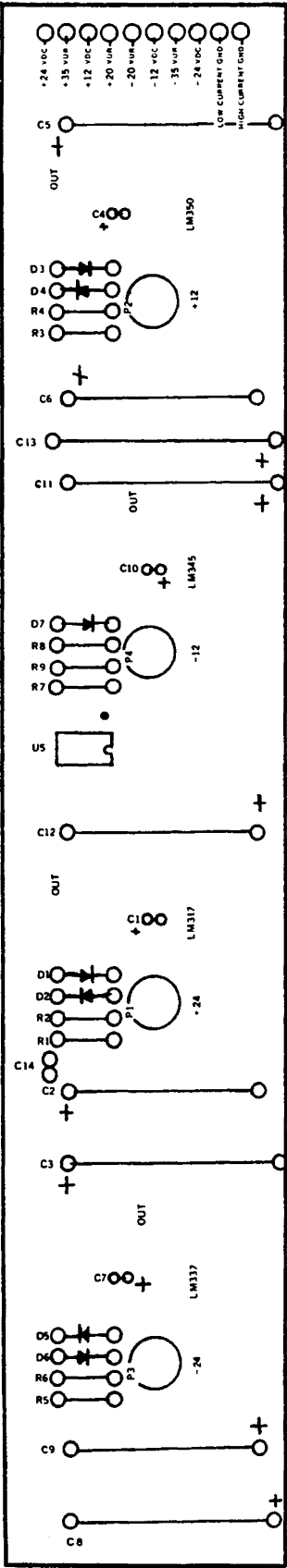


Figure 54 - Regulator Strip

